THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL.

VOL. 23. Thursday, March 10, 1921. No. 238.

PUBLISHED WEEKLY.

Subscription Terms: 15/ per annum.
All Subscriptions are payable in advance.

All communications to be addressed to the Editor, or to the Publisher, as the case may be, of

The Foundry Trade Journal,
BESSEMER HOUSE, 5, DUKE STREET, ADELPHI, LONDON, W.C.2.

Contents.

	PAGE
Notes and Comments	217
Dilatation Determination in Steel	218
Correspondence	219
A New American Brass Foundry	219
Book Review	219
The Composite Process of Carburisation of Steel during Casting	220
Electric Furnaces in the Iron Foundry	221
The Manufacture of Manganese-Bronze Marine Propellers.—Part III.	223
Swedish Electric Pig-iron Furnace	225
Notes on Aluminium Die-Castings	226
Some Difficulties in the Manufacture of Malleable Iron Castings	227
Standardisation in the Testing of Welds	228
Institution of British Foundrymen	232
Trade Talk	235
Company News	236
Deaths	236
Gazette	236
Personal	236
Iron and Steel Markets	237

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTION OF BRITISH FOUNDRYMEN.

LIST OF SECRETARIES—

General Secretary: W. G. Hollinworth, Bessemer House, Adelphi, Strand, London, W.C.2.
Manchester: J. Hogg, 365, Manchester Road, Burnley, Lancs.
Birmingham: F. B. Holberry, 22, Salisbury Road, West Bromwich.
Sheffield and District: W. A. Macdonald, 62, Button Hill, Ecclesall, Sheffield.
Scottish: W. H. Bound, 5, Midlothian Drive, Shawlands, Glasgow.
London: A. Willis, Norfolk House, 324, South Lambeth Road, Clapham, S.W.
Peterborough: H. P. Mason, Prudential Chambers, Peterborough.
Newcastle-on-Tyne: H. A. J. Rang, 2, St. Nicholas Buildings, Newcastle-on-Tyne.
East Midlands: H. Bunting, 17, Marcus Street, Derby.
Coventry: F. H. N. Lane, Queensberry, 2, Dover Street, Coventry.

NOTES AND COMMENTS.

Electric Furnaces in the Iron Foundry.

The article which we publish this week on the above subject is by Dr. Richard Moldenke, one of the leading American authorities upon the metallurgy of cast iron. We can commend a careful and detailed study of his views to all our readers who are interested in making better and cheaper iron castings.

Although, prior to the war, America lagged somewhat behind Europe in the application of electric furnaces to steel making, the United States has undoubtedly taken the lead with the establishment of the electric process in the iron foundry. This is probably due to the fact that, generally speaking, American foundries are run on more progressive lines than are our own, and consequently their foundrymen have not been slow to recognise the advantages that are offered by electric melting or refining.

The considerations governing the choice of raw materials for iron castings are substantially the same in both countries. We have our cheap and inferior grades of scrap, such as burnt iron, borings, and turnings at one end of the scale, and costly high grade pig-iron at the other. Melting in the ordinary cupola necessitates the choice and governs the cost of the materials of the charge, according to the particular quality of the castings to be made. There is also a limit to the temperature which can be attained in the cupola, and where fluidity is required, for very thin work, the chemical aid of phosphorus in the mixture has to be called in.

Once the cupola has been charged and melting has begun, there is little chance to alter the composition or the tapping temperature of the metal. There is also a gain in the amount of sulphur every time the same piece of cast iron is passed through the cupola.

The electric furnace, on the other hand, possesses great flexibility, whether used for melting and refining, or simply as an auxiliary apparatus supplementary to the cupola. Broadly speaking, the composition and physical state of the charge have but little effect on the final result, as the cheapest of raw materials can be used for the highest grade of castings; the metal is purified by the process, and its sulphur content can, if required, be reduced to the lowest commercial limits; the injurious effects of oxidation are eliminated, and the temperature can so be raised as to confer wonderful fluidity upon strong irons of high melting point.

Turning to the question of costs, the main item, when using the electric process, is that for current. Average British power costs are probably double those of America, and on this account we do not think that there is much chance of the electric furnace supplanting the cupola here as a melting unit. The field for the electric process, in our own foundries, is to refine and superheat metal which has been previously melted in the cupola. This field will, of course, be limited to the better grades of castings, as the commonest qualities will always be made from the cheapest scrap melted in the cheapest way.

Where, however, the composition and physical qualities of the metal have to be considered, we believe that the ability of the electric process to deal with cheaper raw materials will offset the cost of refining in the electric furnace. This, quite apart from the fact that fewer wasters and generally sounder castings will be produced by this duplex cupola-electric process.

In the case of the highest grades of iron castings, we are by no means certain that the electric process is not the only one to be used in order to obtain the best results in practice, both from the point of view of quality and ultimate cost.

It is not, of course, every foundry that could afford to put down an electric furnace to use in conjunction with the existing cupolas, as the first cost of the electric equipment is fairly heavy compared with that of a cupola of corresponding output, but we believe that the enhanced reputation of a foundry for the regular high quality of its product would soon increase the value of its goodwill, and turn the capital invested in the electric furnace to profitable account.

Correction.

We regret that in the report of Mr. H. Field's paper on "What is Semi-Steel?" he is made to say: "A semi-steel casting can be definitely selected and recognised by its analysis," whereas what the author actually stated was: "A semi-steel casting cannot . . . analysis."

Queries Answered.

We have been requested by numerous readers to set aside a queries column for readers to ask questions about difficulties in foundry practice. In the past we have dealt with such matters privately, but it seems to be the general wish that our answers should be available for the foundry industry in general.

Dilatation Determinations in Steel.*

By Professor J. H. ANDREWS, D.Sc.

The property of dilatation, that is, expansion or contraction with rising or falling temperature, has not received the attention it merits. All changes of state are accompanied by energy changes, generally speaking a heat change. Supposing for a moment that a change of this nature has occurred during the cooling of a steel, and that accompanying this change is a relatively large expansion, it is quite conceivable that all the energy might be absorbed in bringing about the expansion, so that no thermal effect would be apparent. On this account a dilatation temperature curve is of great value.

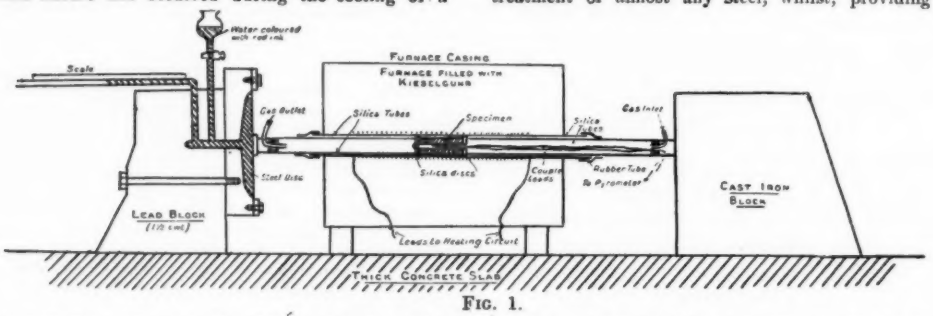


FIG. 1.

A simple instrument for this purpose is illustrated in Fig. 1, which is self-explanatory. Pieces two inches in length, with parallel ends, are found to be the most convenient, whilst if it is required to harden the specimens it is advisable to have a $\frac{1}{8}$-in. hole drilled through, to facilitate uniform quenching.

The normal curve obtained with a 0.9 per cent. carbon steel is shown in (*a*), Fig. 2, in which it is seen that the usual change point at 700 deg. C. takes place with contraction, *i.e.*, due to the transformation of alpha into gamma iron. This represents the type of curve with the steel in a normal condition.

If, previous to taking a heating curve, we quench the steel in cold water from 1,000 deg. C., on again heating up a curve of type (*b*) is obtained; this shows evidence of three distinct critical points, namely, one between 100 deg. C. and 150 deg. C., one between 300 deg. C. and 350 deg. C. and the usual one at 700 deg. C. This curve is typical of all carbon tool steels quenched from a high temperature. The point at 150 deg. C. is just below the usual temperature given to tools after being quenched, whilst that at 350 deg. C. corresponds with the complete softening of the steel.

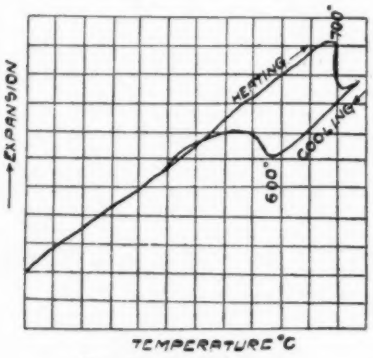


FIG. 3.—CROSS SECTION.

If the quenching is done at, say, 760 deg. C., the points at 350 deg. C. and 150 deg. C. are much smaller (*c*), whereas, if after quenching the steel received the usual low-tempering treatment the lower point will be found wanting (*d*). Now, it is by no means easy, or always possible, to detect whether a tool has been overheated, or whether or not it has received the low-tempering treatment, from the microstructure alone. By means of a dilatation curve, however, both these factors can be readily arrived at. In this instrument we have, then, a ready method of detecting errors in treatment of carbon tools. The actual curve, together with the fixing up of the apparatus, will take at the most half an hour to complete, which, compared with the often unsatisfactory method of micro examination, effects a distinct saving in time, whilst its results are definite and conclusive.

It is, indeed, possible by this means to arrive at the treatment of almost any steel, whilst, providing the piece is of reasonable shape, say in the form of a drill, the article itself may be used without any preparation. Another interesting case presents itself with respect to these dilatation measurements. Supposing there were some dispute as to whether a test-piece had been taken in the longitudinal or cross direction. All that is necessary is to cut the piece up into 2-in. lengths, and take a heating and cooling curve by this method.

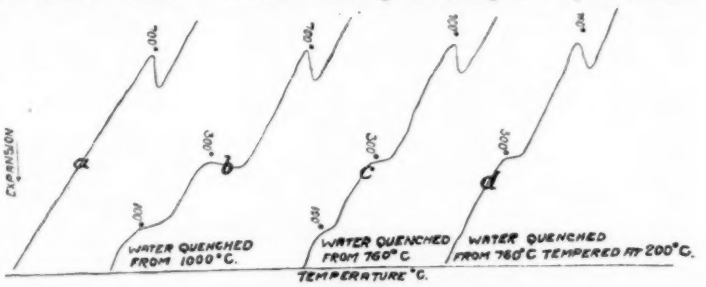


FIG. 2.

According as to whether the section was taken in the cross, radial, or longitudinal direction, we should get

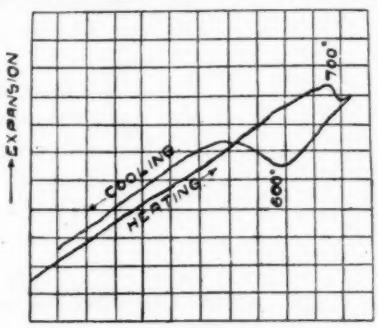


FIG. 4.—RADIAL SECTION.

curves of the form shown in Figs. 3, 4 and 5. These curves differ in the manner in which the cooling curve

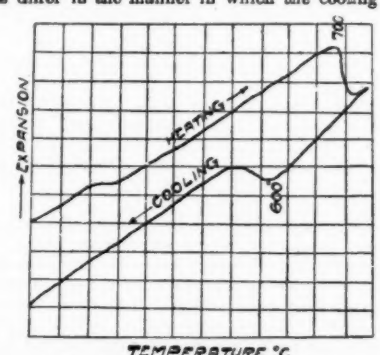


FIG. 5.—LONGITUDINAL SECTION.

returns to the normal; it is noticed that with the cross section, the return is complete, the heating and cooling curves below the critical point being coincident.

* From a Paper on "Defects in Steel and their Detection," read before the West of Scotland Iron and Steel Institute, and printed in the "Journal" of the Institute.

In the radial section, the cooling curve just crosses the heating curve at the lower temperature, whilst a distinct permanent contraction is seen to have occurred in the longitudinal piece. These curves represent the results of repeated tests upon one series of sections only, but as the results are only what would naturally be expected, it may be concluded that they represent the type. This difference in form of the return curve on cooling can only be due to the direction of growth of the dendrites, and to the direction of forging.

Correspondence.

[*We accept no responsibility for the statements made or the opinions expressed by our correspondents.*]

CONCRETE PIPES.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—I was much interested in your extract from Mr. L. H. Thomas's paper to the Midland Junior Gas Association in your issue of February 24. It is obvious that in many directions the concrete pipe has a big future, but I feel that the widespread statements one hears as to the probable decease of the cast-iron pipe are hardly justified. General knowledge of the advantages and disadvantages of the concrete pipe seems to be small, and I should welcome some information on the following points:—

(1) Is the joint mentioned by MR. Thomas the only really satisfactory joint available for concrete pipework? It appears to be an absolutely rigid joint, and if so would be quite unsuitable for use in made-up ground or in colliery districts where there is any likelihood of subsidence.

(2) Is the concrete pipe gas-tight for anything over low pressures?

(3) What is the behaviour of the pipes under heat, *i.e.*, when conveying either hot gases or hot liquids or steam?

(4) What is the effect of a constant passage of water under a heavy load after a considerable period of time.

(5) What is the effect of very hard frost.

I understand that a fine surface skin is obtained on these pipes and I would like to know what effect the conditions mentioned above would have on this as the efficiency of the pipe naturally depends to a considerable extent on the smoothness of the interior and the capacity of the pipe to retain its surface.—Yours, etc.,

KENELM C. APPLEYARD.

[It was reported in a London contemporary last May that the Hume Pipe Company's factory at Germiston (South Africa) had then been working for about two years, and its output capacity was then over 300 tons of pipe weekly. During November, 1920, the Company had obtained extensive orders for their pipes. Thus the Wynberg Municipality had placed a further order for 24-in. and 30-in. piping to the value of about £25,000. The Rand Water Board had ordered over 1½ miles of water pipes for 100-lb. pressure. Our correspondent would, no doubt, be able to obtain replies to most, if not all, his queries by writing to the Hume Pipe Company, 7c, Lower Belgrave Street, London, S.W.1.—ED., *F.T.J.*]

A WORD OF APPRECIATION.

To the Publishers of THE FOUNDRY TRADE JOURNAL.

DEAR SIRS,—We have your favour of yesterday's date, and beg to thank you for kindly bringing this inquiry to our notice. We are quoting our friends for the ladles to-day, and we hope to secure the order.

We may say that we strongly appreciate your kindness in putting the matter before us. We are finding your paper an excellent medium for disposing of foundry plant generally, and we feel sure that your circulation will be very much increased and its utility to the foundry and allied trades advanced by your bold policy in making its issue weekly instead of monthly.

Again thanking you.—Yours, etc.,

HAMMOND & BOTTOMLEY.

33, Mackenzie Street, Slough.

A New American Brass Foundry.

The new foundry of the Lumen Bearing Company is of the monitor roof type, of brick, steel and concrete construction; high, light, well ventilated and heated. The main building measures 105 x 140 ft., and has been equipped to handle 2,000,000 to 3,000,000 lbs. of castings per year.

The railway siding was held up 20 ft. above foundry grade—a feature which permits easy unloading of sand, fuel and metals. As all the material is handled into and out of the plant by railway trucks, this peculiar location of the adjacent railroad was taken advantage of in this way. Fuel oil is drained by gravity into tanks on grade level, housed and steam-heated. Metals are chuted directly to the metal room scales within the main foundry.

Fuel oil is used for melting. It is delivered by pumps to an auxiliary air tank, in which it is put under air pressure up to about 40 lbs. This part of the equipment is housed in a brick and concrete structure, the auxiliary tank being placed below grade level to permit back draining, if necessary. The entire system is protected by Lalor valves that automatically close on a sudden relief of pressure in the line, as happens in the case of line breakage. The whole fuel oil system is enclosed and protected from freezing by a low pressure steam plant. This practice is also of great importance in maintaining uniform melting conditions.

The principal melting units are two U.S. smelting furnaces. There are also six crucible pits intended for small heats, or special metals, or for use in an emergency. Ladle and crane equipment are adequate to pour castings up to 5,000 lbs. in weight.

The main bay is served by a 10-ton Euclid crane. A monorail system covers both side bays, serving hand pour-off cranes for the lighter castings. The view of the centre bay is taken looking toward the cleaning room and away from the main melting furnaces.

The side bay carries the core room and the moulding machines. This item of equipment is the important feature in the problem of making accurate castings. The patterns are mounted on iron or steel plates, and held exactly in place when the sand is rammed. Only by this method can patterns be withdrawn cleanly from the mould, with a minimum of draft, and the consequent saving to the buyer. It is due to the constant improvement of its moulding-machine practice that the Buffalo works of the Lumen Company has been able to reduce its defective casting returns to 0.85 per cent.—"Iron Age."

Book Review.

GUN METAL AND BRASS FOUNDING, by H. S. Primrose and J. S. Glen Primrose. Messrs. Louis Cassier & Co., Ltd., 34, Bedford Street, London, W.C.2. Price 10s.

In this book a happy combination of theory and practice has been effected by the authors. Prominence is given to the mass production of brass castings and the subject of testing. We would suggest that a slight change might be made in future editions by the inclusion of a formula before the calculation of the heat units required to raise the temperature of 1 lb. of metal from room temperature to 100 deg. C. above melting point, such as appears on page 5. This and a few other minor faults do not at all detract from the great utility of the book.

FOUNDRY MOULDING MACHINES AND PATTERN EQUIPMENT, by Edwin S. Carman. Messrs. The Penton Publishing Co., Cleveland, Ohio, U.S.A. Price $5.

This book, though not as well known in this country as its worth warrants, has now reached its second edition. In this edition the book has been amplified by an opening chapter on general moulding principles. Its outstanding feature is the comparison which is established between outputs of various types of castings when machine moulded and hand moulded. We can thoroughly recommend it to those desiring a modern book on moulding machines.

XUM

The Composite Process of Carburisation of Steel during Casting.

By MAJOR WADDINGTON, M.C.

The process of carburising steel, *i.e.*, case-hardening, is familiar to all students of metallurgy; suffice it to say that on account of the length of time it occupies it is inapplicable commercially to any but the smallest manufactured articles, or to exceptional products such as armour plate, etc. It occurred to the author

FIG. 1.—SECTION OF RAIL AFTER NITRIC ETCHING, SHOWING EXTRA CARBURISATION ON RUNNING SURFACE.

some time ago, therefore, to try to produce the same effect in a more rapid, less expensive, virtually direct manner, with the primary object of applying the advantages of such limited carburisation to the upper or running surface of steel rails, though it must be understood that there are many other directions in which the method about to be described may be used.

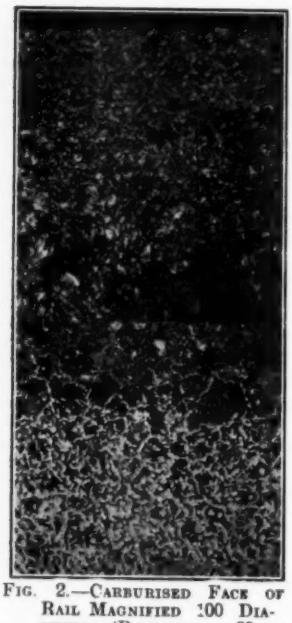


FIG. 2.—CARBURISED FACE OF RAIL MAGNIFIED 100 DIAMETERS (REDUCED TO 50 IN REPRODUCTION).

What might be called the "absorption index"—and by that is meant the power of steel to absorb varying quantities of carbon above a critical temperature—depends upon (1) time and (2) temperature; thus it follows that the absorption index of carbon by steel increases or decreases in proportion to a rise or fall in temperature, and the length of the period in which the two elements are in intimate contact. By causing contact between molten steel and amorphous carbon the rate of absorption is at its maximum, and is thus brought about in the minimum amount of time.

To put this to the test an ingot mould was prepared, and lined on one side only with amorphous carbon blocks or plates, the object in view being to produce an ingot of steel having on one face a greater percentage of carbon than on the other three faces, and subsequently to roll this ingot into a rail, taking care that the extra carburised portion went to form the head or running surface of the rail.

It follows that if this object could be attained the result would be a more economical rail than those which are produced to-day, for, by certain limitations, it would be possible to vary the carbon content at will throughout the section, thus raising the carbon per cent. in the head and keeping it either normal or sub-normal in the foot and web, and by this means prolonging the life in terms of wear, and added efficiency in terms of extra strength and resistance.

A steel produced by the Bessemer acid process was employed, having the following composition:—Carbon, 0.30 per cent.; silicon, 0.10 per cent.; sulphur, 0.086 per cent.; phosphorus, 0.069 per cent.; manganese, 0.810 per cent. A carbon content of 0.30 per cent., of course, is much less than is the usual practice in making rail steel, but this proportion for the bulk of the rail was chosen for the express purpose of counteracting, or compensating, for the increased hardness in the head or running surface which was expected.

In due course the steel was poured into the mould, and a definite reaction was noticed; the ingot was then stripped, removed to the soaking pits for reheating, and afterwards rolled into a 95-lb. British standard rail. No difficulties were experienced in doing this; the carburised portion was well marked, and kept in its correct position during its passage through the rolls—the rail, in fact, behaved in quite an ordinary manner, and there were no signs of localised curvature, etc. The finished rail was clean and straight; test-pieces were cut at the saw, and, on cooling, were proved satisfactory by testing under the falling weight. Smaller sections were cut for etching and micrographic research and record, and from these proof was obtained that the carburisation of steel during casting is possible. Fig. 1 is an etching by a 5 per cent. solution of nitric acid, which on close examination shows a darkened portion—at its maximum about an eighth of an inch deep; this is the extra carburised area and is commercially regular; it is also in its correct position on the head of the rail. Drillings were taken from an average depth of three-sixteenths of an inch inclusive of this carburised area and beyond, which gave a carbon content of 0.50 per cent. Comparing this with the original carbon of 0.30 per cent., there is a difference of 0.20 per cent carbon. The result is interesting and encouraging, but not sufficient, or for that matter, final. Fig. 2 is a small section magnified 100 diameters (reduced to 50 diameters in reproduction), showing the extra carburised portion gradually merging into the normal structure, which at 0.30 per cent. carbon was selected as the base or starting point. The upper portion "A" consists of cementite and pearlite with a micro-analytical approximation of 1.0 per cent. carbon; the middle portion "B" consists of pearlite approximating 0.65 per cent. to 0.80 per cent. carbon; the remaining portion "C" of pearlite and ferrite, which is common to the rest of the rail.

No doubt further trials, by modifying the rate and temperature of casting, and also by altering the composition of the carbon sheets or plates, will provide a much greater degree of carburised face penetration, and consequently a greater difference between the total average carbon content of that area and the bulk of the rail. At this juncture, however, sufficient light has been thrown on the subject by this first experiment to show that the problem is not so difficult of solution as one may have been led to believe.

[Communications on the subject of these trials should be addressed to Major Lomax, 222, Strand, London, W.C.2, who is acting as Major Waddington's representative.]

The Agent-General for Tasmania, in conjunction with Mr. J. H. Butters, general manager of the Hydro-Electric Department of the Tasmanian Government, has placed orders with an English firm for transformers and switch-gear for the electrical installation to be erected at Bridgewater, Tasmania, in connection with the hydro-electric developments in that State. This contract was secured in competition with American firms

The Federation of British Industries is collecting information as to the loss and inconvenience arising out of the incorrect transmission of telegrams. In one particular case a special length of tube was ordered. The figure mentioned was incorrectly transmitted and tubes an inch too long were sent in fulfilment of the order. The Post Office expressed regret, but took refuge behind the conditions printed on each telegraph form.

Electric Furnaces in the Iron Foundry.*

BY DR. RICHARD MOLDENKE.

One of the gravest problems of the iron foundry to-day is the accumulation of sulphur in commercial scrap and its effect on the resulting castings. The ordinary jobbing castings to-day show a sulphur content of 0.18 per cent., and occasionally as high as 0.22 per cent. The product of the foundry during the war is undoubtedly to blame for this rapid increase, and conditions will become worse as the millions of tons of grey-iron castings of the war period return to the foundry in the form of commercial scrap.

In the ordinary cupola remelting of pig and scrap, at least 0.02 per cent. sulphur is taken up: and occasionally double. The high cost and difficulty of obtaining pig-iron during the war period compelled the use of considerable scrap in the mixtures; frequently charges containing 90 per cent. of bought scrap were melted. Naturally the sulphur content of the castings increased.

Until the advent of the basic-hearth electric furnace, the only method of holding the sulphur within reasonable limits was to use high percentages of pig in the foundry mixtures. Pig-iron seldom contains over 0.05 per cent. sulphur, if well made. With pig-iron forming 60 per cent. of the charge and the gates, runners, rejections and bought scrap the other 40 per cent., the sulphur content of the castings can easily be held down to 0.10 per cent. Pig-iron, however, costs more than scrap, even when melting loss differences are considered, hence as small a percentage as possible will be used.

The recent advance in knowledge of rational melting, and the consequent reduction in losses directly due to oxidation of the metal and cold iron, has permitted the acceptance of castings with a much higher sulphur content than formerly. The steel industry also is seeking to determine how high sulphur may go with safety. In the iron foundry, however, there is the danger of a low cupola bed or an unduly retarded air-furnace heat, with the consequent raising of the freezing point of the metal and segregation effects resulting from high sulphur with insufficient manganese. The iron foundryman must, therefore, have a means of correcting his molten metal. The electric furnace, with a basic-hearth, offers this opportunity.

Before the iron foundryman, particularly the producer of grey and malleable iron castings, can pour his moulds safely, the molten metal must have a high degree of superheat, be thoroughly deoxidised and reasonably low in sulphur. A foundryman will get these characteristics if he uses good materials and melts properly. The electric furnace will give a highly superheated metal that is thoroughly deoxidised, and a fine degree of desulphurisation if the hearth is basic. If, for greater economy and to fit existing equipment conditions, the " duplexing " system—cupola metal refined in the electric furnace—is used, the best results for quality are obtainable conjointly with a reasonable cost.

The foundryman may melt cold metal directly in the acid or basic-hearth electric furnace, or he may refine molten cupola or furnace metal in either hearth electric furnace. In duplexing, however, it is doubtful if open-hearth metal will be transferred to the electric furnace; in fact, it is doubtful if even air-furnace iron will be used that way, as in the foundry the air furnace gives 10 to 40 tons of metal at one time, whereas the same tonnage from the cupola is either distributed over 2 to 4 hours or spread over the entire working day. The problem of the electric furnace in the foundry, therefore, resolves itself into either adding the necessary electric equipment for duplexing or installing electric furnaces for direct melting and refining of cold stock. Of the two hearth systems the basic is to be preferred for its specific value in desulphurisation.

Cost of Electric Melting of Cold Scrap.—When cold metal is charged into an electric furnace, unless carefully handled, there will be considerable fluctuations in the current until the pigs or pieces of scrap around the electrodes are melted. As the rest of the charge melts in the bath that forms, the fluctuations become less marked, and when the bath is entirely molten the internal resistance is sufficient to reduce the current demand, in some furnaces, one-half. Melting cold iron ordinarily requires a big current reserve and a higher current cost. Data from steel melting show that melting cold stock consumes up to four-fifths of the total current used; the refining period takes the other fifth. Since, however, refining is going on while melting progresses, the contrast in reality is not so great. Duplexing is not only cheaper, but it is also faster, for melting a cold charge and refining it in the electric furnace might take 2 hours, whereas the refining period after melting would not reach ¾ hour.

The advantage of the melting from cold metal over duplexing lies in the ability to melt whenever desirable, whereas duplexing is dependent on the running time of the cupola. The higher cost of castings by either method, unless the lower grade materials used make up this difference, means that the electric furnace will only be used where quality work is produced. Thus, if the total cost of work is, say, 3c. (1½d.) a lb., it is not likely that the foundryman will add another ½c. (¼d.) to ¾c. (⅜d.); but for work that costs 15c. (7½d.) a lb. this addition matters little. The maker of grate bars will undoubtedly stick to the cupola, whereas the producer of piston rings is already beginning to use the electric furnace.

Influence of Electric Furnace on Methods.—A foundry melting metal all day is the exception. The general custom is to keep the men moulding until blast is put on and melting begins, which is usually so timed that the heat will be completed as near finishing time as possible. When the first iron comes over the spout, the men stop work and prepare to pour their moulds. In the malleable industry, particularly with furnace iron or where the nature of the castings lends itself to the purpose, melting goes on all day, as in a large cast-iron wagon-wheel shop, and moulders mould continuously while a special gang pours. This is the ideal way of conducting operations.

Electric furnaces of large tonnage are expensive; a 3-ton outfit, which ordinarily would be considered quite large, now costs about $35,000 (£7,000). For a moderate degree of refining—that is, superheating, deoxidation, and desulphurisation—the metal, as taken from the cupola, should remain in the electric furnace at least ½ hour. With running repairs after tapping out fully ¾ hour will be required for each batch of molten metal. For an average foundry, melting say 20 tons daily in a 50-in. cupola, the heat will last 2 hours, which permits the treatment of only half of it by the duplex method. Unless the product of the establishment can be divided into high-grade and ordinary work, the duplex process will be difficult to instal with the present daily routine. Foundries can do this in most cases, hence an electric furnace equipment added to the ordinary foundry will work out very nicely.

Where it is necessary for uniform quality the entire heat must be melted from cold stock or duplexed. As by using high-sulphur pig-irons, large percentages of low-grade scrap, briquettes of borings, punchings, shot, etc., it is possible to get from the electric furnace, when melting cold stock, as cheap a molten metal, fully refined, as from the cupola, duplexing will not be required, and electric furnace heats may be taken off all day long if desired. But unless the shop is run on the continuous system the owners will hardly care to make the necessary changes in methods such a radical operating departure produces, unless accompanied by a complete shut-down during the transition arrangements.

Advantages of the Basic-Hearth.—The selection of the basic-hearth electric furnace involves several considerations. In the acid-hearth furnace slag manipulation is easier; deoxidation is readily accomplished by providing a slag cover with additional periodic charging of fine coke on this to hold the furnace atmosphere neutral. The intense heat of the bath, with its high carbon percentage, takes care of all oxygen that may be in the metal in some combination. The disadvantages of the acid-hearth furnace are that, whether melting cold

* Extracted from the proceedings of the American Institute of Mining and Metallurgical Engineers.

metal or duplexing, it is necessary to start with comparatively good material, as the sulphur question remains. Further, there is a marked addition of silicon in the bath by reduction from the silica hearth and slag, if refining is carried on for any length of time. The advantages of the acid-hearth are the cheaper refractories, life of the furnace body, and easier slagging conditions. Where, therefore, the question of extremely low costs is not so serious an item, there is no reason why an acid-hearth electric furnace should not be used for melting from cold metal, for the sulphur can be held down by using high percentages of good low-sulphur pig-iron—the melting process gives no additional sulphur, as is the case in cupola melting.

In view, however, of the sulphur conditions in purchased scrap and the desirability of holding down the sulphur maximum, the basic-hearth electric furnace should be used in every new installation, whether for cold melting or duplexing. Nothing prevents running an all-scrap heat through the cupola for ultimate refining in the basic-hearth electric furnace. The carbon conditions can be regulated in the cupola sufficiently, or if necessary in the electric furnace by steel scrap additions, if time can be given for this purpose. The silicon can be increased, if desired, by adding ferro-silicon and such elements as nickel, chromium, titanium, etc., provided by direct or ferro-alloy addition, or preferably and far cheaper in the pig-iron originally used.

Control of Phosphorus and Manganese.—As the electric furnace for the foundry is intended to improve the molten metal only in regard to initial heat, freedom from oxygen in some combination, and elimination of sulphur to the desired minimum, the question of a possible phosphorus reduction does not come up. In fact, unless the steel stage is passed through, this is out of the question. The iron foundry deals with three ranges in phosphorus. In the malleable casting the phosphorus must range from practically nothing to a maximum of 0.200 per cent. For grey iron, the low range is anything under 0.300 per cent.: actually it will be around 0.175 per cent., and results from using Bessemer pig-iron or the "malleables" in the mixture. Heavy castings should not exceed 0.300 per cent., also the lighter sectioned work of large dimensions, particularly when ribbed—as in condensers for marine purposes. Ordinary castings have about 0.500 per cent. phosphorus, this range being from 0.300 to 0.700 per cent. The high range is anything above 0.700 per cent., and is confined to light castings of an ornamental nature, such as stoves and radiators. Foundrymen have no difficulty with their phosphorus, as it can be regulated by suitable purchasing of pig and scrap.

Whenever the product of a foundry runs below 0.50 per cent. manganese there must have been defects in the melting practice, involving undue oxidation during the operation, unless the mixture was too low in manganese in the first place. Where, with sufficient manganese in the mixture, the castings come out below 0.50 per cent. either burnt scrap has been used or the bed of the cupola was too low and free oxygen from the blast attacked the melting iron. The manganese percentage in such a case was insufficient to cart effectively for the surplus oxygen and by uniting with it enter the slag: hence oxidised metal with pinholes, excessive shrinkages, cracks, etc., was produced. With high sulphur in addition, none of this can be neutralised by available manganese, hence further trouble. With thorough deoxidation and desulphurisation effected in the basic-hearth electric furnace it is possible to start with lower manganese ranges in the mixtures: indeed, it is necessary to start with lower manganese, otherwise that part of it in the mixture intended to counteract excessive sulphur, were the castings made directly from the cupola, will on desulphurisation in the electric furnace remain behind and act as a hardening agent.

The metallurgical aspects of the basic-hearth electric furnace operation are interesting: To desulphurise rapidly and well it is necessary to keep the lining in good shape and to charge lime with a little fluorspar to form an active slag on the molten metal. Crushed coke is also charged on the slag in order that the interior atmosphere may be kept neutral to reducing. The more active the lime the quicker is the reduction in sulphur. Calcium carbide is formed, and the bath is both deoxidised and desulphurised. A shallow bath is quicker than a deep one, for the greater the slag and metal contact area the better is the interaction. While it is possible to get the sulphur content as low as 0.009 per cent. this reduction is not necessary in ordinary practice. Reductions to 0.04 or 0.05 per cent. are quite sufficient, for to go lower requires a rapidly-increasing proportional current and time consumption.

Cost of Melting in Electric Furnace.—The matter of costs is a wide subject, for much depends on the furnace used. In the figures here given a fairly high average has been assumed.

Comparative results between the acid-hearth furnace melting from cold metal and basic-hearth duplex melting are shown in the following table, in which the conversion from dollars has been made at par. The cost per net ton of metal in the ladle, when making 300 casts per annum with a 3-ton electric furnace is given.

	Cold Metal Melting Acid Hearth.	Duplexing Basic Hearth.
Current at ¾d. per kw.-hr.	£1 13 1½ ...	£0 6 3
Electrodes at 4d. per lb.	0 6 8 ..	0 2 6
Refractories	0 1 10½ ...	0 6 3
Labour	0 10 5 ...	0 6 3
Depreciation	0 8 4 ...	0 8 4
	£3 0 5 ...	£1 9 7
Add cupola melting cost...		0 16 8
		£2 6 3

If all the metal of a foundry were duplexed it would be possible to effect a saving in each of the above cases of practically the whole amount through the ability to use briquetted borings, steel, malleable, stove-plate and other scrap—to the exclusion of practically all pig-iron—whether these are melted in the cupola or electric furnace. In pre-war time the ordinary cupola mixture might have cost $15 (£3) a ton, but in certain sash-weight foundries the mixtures would only cost $6.50 (26s.). To-day metal equal to charcoal iron is produced in the electric furnace from burnt soda-kettles, burnt stove-grates, spring beds, old annealing pots, etc. On the other hand, where only part of a cupola heat is to be duplexed, or where time is not available for an extended refining treatment, in the case of electric melting from cold charges, the ordinary run of cupola mixtures must be used to ensure the desired results.

If all foundrymen were to use the undesirable types of scrap on the market, these would soon be sold on the metallic iron content and compete directly with pig-iron. With a good metallurgical laboratory a foundry could accomplish much in the way of cost reduction where a basic-hearth electric furnace is available.

The interesting point to be noted from the costs given is that an ordinary foundry prepared to duplex some or all of its cupola metal, the additional cost is but one-sixth of a penny per lb., because of all compensations in the form of lighter runners and gates, due to the intense heat and wonderful fluidity of electrically-refined cast-iron, and as the number of castings misrun is much smaller than in the present practice with cupola or furnace, and as the quality of the work is unquestionably higher, this one-sixth of a penny becomes at least a part of a penny received.

Temperature of the Iron.—Electric furnace cast-iron is extremely hot; it is snow-white, and when poured into the moulds remains liquid for a long time. The feeding qualities of the metal are demonstrated by the sinking down of the runners and risers. As the resulting castings are close-grained and apparently sound, this kind of iron can be used for high-pressure valves and fittings and other important constructional work. The moulds must naturally be made of very refractory sand, and the partings be tightly clamped. The fluidity and length of time required for solidification make possible the cutting out of many runners and risers and a reduction in volume of those necessary. This, with the smaller runner sections and the ability to flow long distances before showing signs of cold-shuts, should make the subject an attractive one for those foundrymen who would be benefited by such valuable characteristics.

The Manufacture of Manganese-Bronze Marine Propellers.—Part III.

By W. Lambert.

Melting the Metal.—In common with all high-class castings made in manganese-bronze, the metal used for casting solid propellers and blades is remelted metal, which has been previously made and cast into ingots of 28 lbs. weight, or into billets of 10 cwts. each.

For small casts, the metal is remelted in graphite crucibles or pots, but for heavy castings the metal is remelted in large open-hearth reverberatory furnaces. The latter are specially constructed of superior refractory brickwork with a sloping hearth or "apron," and a "well" to contain the molten metal. A tapping-hole is provided which is temporarily closed during the melting operations. A series of doors permit easy access to all parts of the furnace hearth for the charging, stirring, and inspection of the metal during the various stages of the operation.

For castings required to give high tests, all new metal, or a mixture of two-thirds new metal with one-third of approved scrap, *e.g.*, heads, runners, overflows, turnings, and borings, ingot of propeller bronze may be used. No scrap other than bronze of the same brand should be used in admixture with the new metal. In the case of the highest class propeller work, the total weight of metal to be charged as compared with the finished weight of the propeller should be approximately as 2:1. The weight of metal primarily charged into the furnace is dependent upon the capacity of the "apron" and the nature of the charge, whether ingot or billet metal. It is always preferable, where possible, to charge the furnace with large scrap-billets, heads, overflows, etc., because a charge composed entirely of ingots cannot be introduced except by instalments, and more time is required to melt the metal. This is due to the fact that ingots, when beginning to melt on the apron, coalesce into a solid mass and require very considerable effort to effect their dislodgement into the well. A certain amount of any casting charge is sure to be of ingots, some of which may be placed in the well, but it is always advisable to retain a certain number of ingots as "coolers" in case the furnace temperature is inclined to run hot.

When a cold furnace is to be charged entirely with ingot metal, only about 50 per cent. of the total weight should be placed upon the apron; the charging door should be closed and the furnace lighted up. The metal will gradually melt and run down into the well of the furnace. On account of the difficulty mentioned above, the ingots may require to be forced into the well by means of a crowbar, thus leaving the apron free to receive the remaining portions of the charge, which, in small lots, should be introduced upon the apron through the "peep-holes" or smaller doors. When all the metal is melted down, the bath is ready for any final additions which may be necessary.

The temperature of the furnace must be carefully regulated to avoid excessive heating with attendant "gassing" of the metal, and also oxidation of zinc. The temperature of the bath of molten metal should, throughout the melting operations, be maintained only sufficiently above the freezing-point of the particular alloy in use as will ensure a margin of temperature for successfully carrying out the casting operation. The temperature of the bath is ascertained from time to time by the insertion of a pyrometer, after a careful rabbling of the metal.

The liquid metal, collected in the well of the furnace during the operation of melting, should not be violently or too frequently rabbled. Inattention to this point results—by exposure and oxidation of the uncovered metal—in a liability to the production and inclusion of oxides, and consequent alteration of the composition of the original metal. Judicious rabbling, however, is essential to ensure homogeneity in the bath of liquid metal. The total time from charging a cold furnace to the completion of melting will be from five to eight hours, according to the weight and form of the charge and the working of the furnace.

Casting Operations.—The operations immediately concerned with the actual casting of a solid propeller or a blade may be summarised in sequence as follows:—(1) Pyrometric control of the metal in the furnace; (2) control of "zinc-equivalent"; (3) tapping-out and skimming; (4) pouring the metal; (5) skimming the metal in the mould; (6) feeding.

The pyrometric control of the temperature of the metal in the furnace, more particularly when the major portion of the metal is melted, is of paramount importance if high-grade castings are required. The best pyrometer is of the thermo-couple immersion type, and consists of: (*a*) The indicator with flexible leads and connector. (*b*) The stem, or thermo-couple. The indicator employed is very sensitive, although of robust construction, and is well suited for foundry use. It embodies a coil of wire moving in a magnetic field, actuated by the e.m.f. generated upon raising the temperature of the thermo-couple. To the coil is attached a needle, or pointer, which moves over a scale graduated in degrees centigrade.

The stem or thermo-couple, known in the foundry as the "stick," is composed of two thick metal wires of dissimilar composition, which are insulated throughout their lengths, except at the fire-end, where they are twisted and fused together to form a junction or couple. The insulation of the two wires throughout the length of the stick is ensured by threading porcelain sleeves upon each wire, and which if broken may be easily replaced. The whole is then enclosed in an arrangement of iron and steel tubing.

In order to determine the temperature of a bath of molten metal the fire-end of the stick is inserted into the metal to a depth sufficient to ensure that the junction is heated to the same temperature as the metal—about 6 in. will be found sufficient—care being taken that enough time is allowed for the junction to attain the maximum temperature of the bath of metal before the reading is taken. The wires at the free end or head of the stick are connected to the indicator by means of the flexible leads, and the maximum temperature of the metal is indicated by the needle or pointer traversing the scale. It is obvious that the operator must exercise the necessary precautions against the registration of the flame heat of the furnace gases instead of the temperature of the molten metal.

A temperature of 880 to 980 deg. Cent. may be regarded as the approximate limits covering the range of temperatures during any time the metal is in the molten condition. The temperature figure to be aimed at immediately before tapping-out the metal is naturally higher than the actual casting temperature, and depends upon variable factors, namely: (*a*) The freezing-point of the metal; (*b*) the bulk and cooling-rate of the metal: and (*c*) the interval between tapping the furnace and pouring the metal into the mould. The freezing-point of manganese-bronze necessarily depends upon the actual composition of the alloy, but for all practical purposes one may assume that freezing commences at about 880 deg. Cent. The rate of cooling varies inversely as the bulk of the metal, so that a small charge requires to be tapped at a higher temperature than a large charge.

Control of the Zinc-Equivalent.—This control is highly important because of the readiness with which zinc oxidises; any excessive furnace temperature may cause a serious diminution of the amount of this metal in the alloy. The control is carried out in two ways, according to the type of metal in the furnace: (*a*) By observation of the "sparkle" to be seen upon the freshly broken surface of a fractured bar; (*b*) by micrographic computation of the alpha and beta percentages in such alloys as show no sparkle. Before the metal is tapped from the furnace small ingots are cast in open-topped horizontal moulds of cast-

XUM

iron. Such ingots furnish the necessary bars upon which control-determinations are made either by visual comparison with standard fractures, or by microscopic analysis, as may be necessitated by the nature of the particular alloy.

This adjustment of the zinc-content immediately before tapping the furnace is rendered imperative, as it is obviously impossible when compounding the bronze to accurately calculate the loss of zinc occasioned on remelting the bronze in an open furnace. Such loss is dependent on (*a*) the period during which the metal is molten, (*b*) the temperature of the metal, (*c*) the nature of the atmosphere maintained through the melting operation, and (*d*) the exposure of the metal due to rabbling or stirring. The loss of zinc is corrected by the addition of pure spelter to the molten metal, the amount to be added being determined by an experienced metallurgist in the manner indicated. The bath of metal having been adjudged to be correct both as regards composition and temperature, is then tapped from the furnace into a capacious container of sufficient size to take the whole quantity with ample margin to permit of its being safely lifted and carried by a crane to the mould. Tapping-out should never take place until it has been ascertained that everything is in readiness for the metal to be transferred from the container to the mould.

A "runner-box," Fig. 4, of such dimensions as to hold about one-third of the gross weight of the casting should be in position immediately over the runner or entry to the mould, a ball-plug sufficing to temporarily seal the opening in the

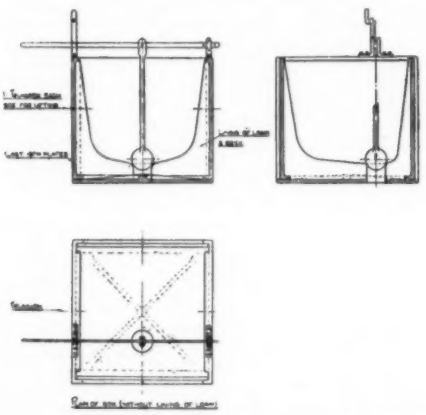


Fig. 4.—Showing Runner Box.

bottom of the box. Both the container and the runner-box are lined with refractory material of low thermal conductivity, and are also preheated before introducing the metal in order to guard against premature chilling of the same. The metal in the container is expeditiously and carefully skimmed free from dross by an experienced man using a heated skimming-iron, and is then carried to the runner-box and a portion of the metal transferred thereto and finally introduced into the mould by raising the ball-plug, the level of the metal in the runner-box being maintained by the addition of further metal from the container. The runner-box serves a dual purpose, in that being constructed to effect bottom-pouring only clean metal is introduced into the mould, and also being raised above the highest portion of the mould, it ensures the necessary head of liquid metal to force the bronze from the bottom of the mould upwards to the top of the feeding-head above the boss in the case of a solid propeller, and above the flange when casting a single blade. It is of great importance that the flow of metal from the runner-box to the mould should be uniform and unimpeded. Any irregularity or checking of the flow of metal is apt to cause "over-lapping," that is, layers of metal solidifying independently. Care must necessarily be exercised to guard against the inclusion of dirt, dross, and splashings, etc., and all such matter likely to be trapped by the casting must be carefully directed during the casting operation in such manner that it is all subsequently collected in the discard from the top of the casting.

Skimming the Metal in the Mould and Feeding the Casting.—The mould, having been filled, and any surplus metal discharged, the surface of the metal in the head is then skimmed free from dross, etc., by suitable skimming-irons, and the casting has then to be fed. This feeding is accomplished by one or both of the following methods: (*a*) Use of feeding-rods. (*b*) Additions of hot liquid metal.

In the former method, spoken of in foundry parlance as "pumping," heated wrought-iron rods are moved by hand up and down in the metal in the head of the casting until solidification takes place, the depth of immersion of the rods being lessened as solidification progresses. In the latter method, a liberal supply of hot liquid metal of the same quality as used in the main casting is directly mixed with the metal in the head of the casting. This feeding-metal is carried in crucibles direct from small melting-furnaces, and its introduction into the head of the casting serves not only for feeding, but tends to liven up the more or less sluggish metal to which it is added, and for this reason should be hot.

The operation of feeding has for its object the following-up by the molten metal of the contraction, which takes place when the metal passes through the transition stage from the liquid to the solid, and also during the subsequent cooling down of the solid metal. If feeding is not resorted to, as also if the operation is not skilfully performed, contraction cavities or "draws" will be found in the surface exposed by cutting off the head, and also when boring out the boss.

With heavy castings of 2 tons and upwards the head must be kept liquid for a considerable period, as this portion of the casting must obviously be the last to solidify if it is to perform its full function. Castings of such heavy weight are kept "open" in the head by the addition of 2 or 3 tons of molten metal introduced in quantities of, say, 5 cwts., at comparatively short intervals as may be considered necessary.

Stripping the Casting.—When the metal as a whole has set and cooled somewhat, it is desirable to uncover certain portions in order to prevent distortion by internal stress, and also as a means of controlling the thermal treatment during the cooling out of the casting. The grain-size of the metal is materially influenced by the rate of cooling, and as previously stated the judicious application of ways and means of accelerating or retarding this rate of cooling, acquired as a result of long experience, plays an important part in ensuring to such castings practical immunity from subsequent failures attributable to casting-stresses and abnormal grain-growth.

The operation of stripping the hot casting is one requiring very great care. Undue haste must be avoided or contraction cracks may develop, and all work must be conducted without shock, as otherwise the metal, being at such a time in its weakest condition, may be seriously damaged. The period during which the above thermal treatment is controlled depends upon the weight and bulk of the casting, and two or three days elapse in the case of the heavier castings before the whole mould is stripped from the casting.

The propeller or blade, immediately after removal from the mould, is stamped with the works sequence number to ensure its identity being preserved. It is desirable to ascertain and record the weight of the casting complete with head and runner, as such weight, together with the overflow, affords a check on the furnace and casting-losses. A test-bar cut from the actual casting is then removed and tested in order to ascertain that the metal is up to specification, and the test proving satisfactory, the casting is cleaned free from all adhering loam and critically examined before being passed on to the fettling shop.

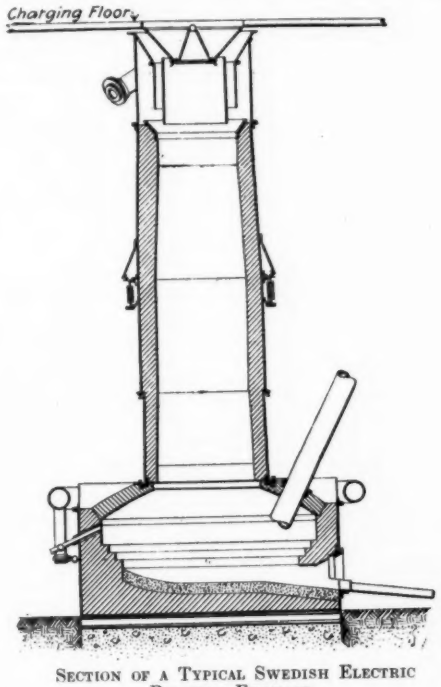
Fettling the Casting.—Before passing on to the machining department the propeller-casting is roughly trimmed, the runner removed, and any surface excrescences due to cracks in the loam, etc., are removed by chipping. Pneumatic hammers are used exclusively for this class of work.

Mr. John Hodge, M.P., has been presented with his portrait by the British Steel Smelters' Association, which is now part of the Iron and Steel Trades Confederation, of which he is president.

Swedish Electric Pig-iron Furnace.

In a recent issue of "Chemical and Metallurgical Engineering" MR. JONAS HERLENIUS summarises some of the results from a Swedish electric pig-iron furnace used as a commercial unit for iron-ore reduction. Annexed is a section of a typical modern furnace, the shaft being designed in accordance with the general practice for common blast furnaces, except for a recent tendency to widen out the lower section, making the diameter of the shaft at its junction with the crucible even larger than at the bosh. The entire brickwork and shell plate of the shaft are suspended independently of the crucible. A steel ring is attached to the shell plate and rests on brackets and cross-girders supported by three or four columns, either a part of the furnace building or preferably independent of it. The bottom of the shaft is an iron ring, which makes a flexible joint with a corresponding water-cooled ring serving as a skewback for the bricks in the crucible roof. The shell has an extension of from 6 ft. to 9 ft. above the stock-line and carries the charging bell. In this extension, openings are made for the gas outlets. The crucible is cylindrical and is contained in a mild-steel shell resting on beams supported by a concrete foundation. The electrodes are inserted through the thin brick roof at an angle of about 65 deg. to the horizontal. The entire shaft is lined with firebrick and the thickness of the wall is about 18 in. for the upper and middle sections and about 14 in. for the lower. The crucible is also usually lined with firebrick, although lately rammed-in coke or waste electrodes have been used with success both in the bottom and in the side walls. The roof is lined with special-shaped firebrick. To prevent it from raising, on account of the gas pressure within the crucible, an outside latticed steel construction suitably braced and connected to the shell plates is provided.

A portion of the gas is returned to the furnace by means of exhausters, or, in order to assure a constant supply, by a separate rotary blower of the same



SECTION OF A TYPICAL SWEDISH ELECTRIC PIG IRON FURNACE.

capacity, but operating under a pressure of about 20-in. water gauge. This gas is forced into the free space between the charge and the roof of the crucible, through a number of tuyeres in the wall. They are supplied from a bustle pipe and point upward to blow the gas directly underneath the roof in order to cool it. There is consequently a certain quantity of gas circulating through the furnace, which is beneficial for the pre-heating of the charge in the shaft and for facilitating the preliminary reduction of the ores. The volume of this circulating gas is constant and the gas formed during the process is, therefore, available for heating auxiliary boilers or furnaces in the plant. For this purpose it is of particular importance on account of its high B.T.U. value.

The electrodes used are almost exclusively made of amorphous carbon and number from four to eight, depending on the capacity of the furnace. They are round, 24 in. in diameter, have nipple joints for continuous feed and can be loaded up to about 16,000 amp. Heavy water-cooling boxes and gas glands are placed in the apertures where the electrodes enter the crucible roof, and close to them are water-cooled contact clamps of copper directly connected to the busbar work. As the power input is regulated by changing the potential on the transformers, there is no need of electrode adjustment except as they are consumed.

At the flexible joint between furnace shaft and crucible there is a water-cooled ring. In the shaft brickwork, at the tap hole, tuyeres, etc., there are water pipes and coolers in accordance with standard blast-furnace practice. Further, most furnaces lately installed have a complete water-spraying device for the entire shell of the crucible. In addition, water is required for cooling the transformers, exhausters, gas conduits and for cleaning the gas. It is therefore of utmost importance that an ample water supply be provided at suitable pressure and that the operation of the system be safeguarded against breakdown. The crucible roof is air-cooled on the outside by means of blast supplied from a small rotary blower connected to a 5-h.p. motor.

Electrical Equipment.—The operating current for this type of furnace may be either two-phase or three-phase, depending upon the furnace capacity. The average-size furnace has about a 3,000- to 4,000-k.v.a. transformer bank, consisting of three single-phase transformers which are delta connected on the primary, while the secondary supplies six electrodes. Larger furnaces have two single-phase transformers, which are Scott-connected for incoming three-phase, giving a two-phase, four-wire system. Each secondary conductor is then connected to two electrodes, making a total number of eight. The secondary voltage can be regulated in eight to nine steps, from 55 to 110 volts for charcoal, or from 35 to 70 volts for coke furnaces by means of reduced-capacity taps on primary coils. The incoming primary current on the different Swedish installations varies from 6,800 to 20,000 volts, and in each case is stepped down directly to the operating voltage of the furnace. The number of cycles does not seem to have much bearing on the matter, as there are installations on 25- and 50- as well as on 60-cycle current.

Working Staff.—The operation of the electric pig-iron furnace requires the same class of labour as common blast furnaces. For an installation of two furnaces the following staff is necessary: One superintendent, one assistant superintendent, two chemists, three foremen, one electrician, one crane operator and eight common labourers per shift. In addition there will be required two men per shift for loading charcoal, and from three to five men per shift for unloading and crushing the ore.

Production of Grey Iron.—On account of the intense heat of the arcs from the electrodes a certain amount of calcium carbide is formed, which evidently has a deoxidising effect on the iron. This carbide slag will also eliminate some of the sulphur, although not to the extent that would be expected. As a matter of fact, the desulphurising in these furnaces in usual practice is less than in the ordinary blast furnace, which, of course, is due to the lower temperature. However, with high-powered furnaces lately installed, sulphur has been successfully eliminated by an ample power input producing an iron of grey fracture and high silicon.

Most furnaces operate with a slag of about 1.4 to 1.5 silicate degree (a sesquisilicate), which is satisfactory, especially when the bottom is made of crushed coke. Preferably, however, the silicate degree should be lower and down to 1.0 (a singulo-silicate), in order to avoid bad corrosion from a more acid slag.

Furnace Gas.—The temperature of the gas is about 200 to 260 deg. C. The dust contained in the gas was investigated in Trollhättan and found to be 4.63 grammes per cub. m. gas (of 0 deg. C.) in the downcomers from the furnace shaft, and after cleaning the content was reduced to 0.88 gramme, and in the bustle pipe to 0.62 gramme. An average analysis of the gas from this furnace shows results as follows:—

	Volume Per cent.		Volume Per cent.
CO_2	23.49	CH_4	1.52
CO	63.15	N	1.49
H	10.35		

The weight of 1 cub. ft. of dry gas was 0.081 lb., and the heat value 2,297 cal. per cub. m., which is equal to 258 B.T.U. per cub. ft. dry gas.

Repairs and Renewals.—Recent figures of electrode consumption are rather high, probably due to their war quality. Previous to the war it required from 11 to 15 lb. per ton of pig produced, and the greater part of this consumption is due to the carbon dioxide of the gas being reduced by the incandescent carbon to CO. In regard to the life of refractories, the weakest point in the furnace is the crucible roof, parts of which must be renewed, as they burn out during the course of operation. For a large furnace installation of five units during 1917, the total production of pig-iron was 29,255 tons, and the total quantity of brick used was 416 tons. For 1918 corresponding figures

were 25,791 with 391 tons of brick, and for 1919, 22,350 tons, consuming 380 tons of refractories. A complete relining of the crucible roof can be accomplished in about five days, using a force of 16 men, and a complete relining of the entire furnace will take about one month. An installation of one furnace will have a load factor of about 76 to 77 per cent., whereas for several furnaces the load factor will increase and approximate 80 per cent. The power factor is, of course, dependent on the number of cycles, but will average about 90 per cent. for 25-cycle current. The efficiency of the furnace is about 70 to 75 per cent., based on the experience with the Trollhättan installation.

Operating Results.—The results obtained from the operation of these furnaces are naturally greatly influenced by local conditions at the various plants, as, for instance, the number of furnaces installed, the capacity and the power behind each unit, the kind of ore used and the character of the pig-iron produced. In the following table some actual results during the first seven months of 1920 are given from the operation of a large plant of several units, having a transformer capacity each of 3,000 to 4,000 k.v.a. :—

	Furnace 3	Furnace 5
Total ore used, metric tons	5,733.20	6,310.41
Total lime used, metric tons	568.74	742.80
Total ore and lime used, metric tons	6,301.94	7,053.21
Total charcoal, lbs.	2,957,440	3,112,640
Total current, kw.-hr.	9,576,200	9,001,700
Operating time, hr. and min.	3,736 5	2,989 35
Idle time, hr. and min.	167-45	97-25
Total time, hr. and min.	3,903-50	3,087
Produced pig-iron :—		
Open-hearth, metric tons	365	3,483
Bessemer	3,307	—
Total metric tons	3,672	3,483
Electrodes, lbs. per metric ton pig ...	17.6	19.3
Charcoal, hl. per ton pig (hl. = 40 lbs.)	20.1	22.3
Kw.-hr. per metric ton pig	2,605	2,580
Average load in kw.	2,565	3,020
Pig-iron per day in metric tons	22.5	27.1
Per cent. pig of ore charged	64.2	55.25
Per cent. pig of total charge	58.3	49.40
Lime in per cent. of ore	9.95	11.75
Idle time in per cent. of operating time	4.47	3.23

The total present cost in the United States of a complete electric pig-iron plant with one furnace of 4,000-k.v.a. transformer capacity is estimated at about $150,000.

Correspondence on this subject should be addressed to Messrs. Electro-Metals, Limited, 56, Kingsway, London, W.C.2.

Notes on Aluminium Die-Castings.

F. A. Livermore, M.I.M.E.

Die-casting may be defined as metal castings made by forcing molten metal under pressure in a metallic mould or die. It is necessary to keep this definition in mind to avoid confusing this process with other permanent mould casting processes.

The fundamental principles of the process have been known and practised many years. The simplest application is embodied in the modern linotype machine, in which molten metal (usually tin-lead alloys) is forced under pressure into a metallic mould, the pressure is derived from a piston and cylinder immersed in the molten metal.

Only alloys of comparatively low melting point can be successfully die-cast, but the finished castings are extremely accurate and free from all irregularities. Aluminium die-castings not exceeding 1 in. in any dimension can be obtained with an accuracy of .0005 in.; most complicated patterns can be successfully die-cast when properly designed dies are used, the resultant castings possessing well-defined outlines and smooth surfaces which can be polished without intermediate machining.

Motor-car, motor-cycle and accessory manufacturers have found die-casting well adapted to the small parts of magnetos, gas and electric meters, automatic machines, carburetter parts, hub caps and petrol filters. It is interesting to note the wonderful development of the process, inasmuch as that die-castings in aluminium of 30 to 40 lbs. each are now being turned out in considerable quantities. The characteristic high thermal conductivity, as compared with iron and steel, has considerably augmented the production of aluminium pistons and other parts for automobile and aeroplane engines which are subject to severe and enormous strain at high temperatures when the tensile strength of the metal is generally very poor and would have a strong tendency to brittleness.

Die-Casting Machines.—The basic principles of die-casting machines are similar in practically all designs. Metal, in a molten state, is forced up along a tube of refractory material and through a nozzle into the mould. For aluminium die-casting the metal is melted in a lined metal crucible fixed inside a gas or oil heated furnace. The crucible is fitted with an air-tight cover, and attached to it is a cylinder of compressed air provided with a valve. Thus by opening the valve the pressure exerted from the cylinder forces the molten aluminium through the nozzle into the dies.

Dies. — In the first attempts to die-cast aluminium the problem of obtaining a suitable die material presented serious difficulties, as constitution, coupled with design, form perhaps the most vital factors in the successful operation of the process.

This problem, however, has been solved by the use of various alloy steels. The proper gating and venting of the dies are also problems that arise daily, and on the solution of these problems largely depend the success or failure of the operation.

Alloys.—The constitution of a good die-casting alloy is a subject of unusual interest. A few of the important requirements outside of the usual physical properties demanded of alloys are:—(1) The solvent action of the alloy on the iron containing pot must not be too great. Molten aluminium dissolves iron very rapidly, and analyses of aluminium die-castings on the market will show an iron content of from 1 to 3 per cent., due to this high solvent action. Although the presence of iron in aluminium presents no serious objections in the casting alloys, the absorption of the above 3 per cent. iron considerably raises the melting point, and the alloy becomes viscous and unsuitable for making castings. (2) The elongation of the metal is of vital importance in determining the die-casting properties of an alloy. Not only is it desirable to know the elongation of an alloy when cold, but it is of greater importance to determine the elongation at various temperatures varying from the melting point of the alloy down to normal temperatures. The reason for this becomes obvious when the physical phenomena of the die-casting process are considered. Assuming that a 12 in. diameter ring is to be die-cast in a metallic mould around a metallic core. When the molten metal comes in contact with the mould, it changes its state, and on solidifying it is accompanied by a reduction in volume, called shrinkage. The metallic core not being compressible retains its size and form, so that the die-casting is subject to "stretching" action, and if the elongation of the alloy at this temperature is not high enough to withstand this stress, the casting will crack.

It is well known that the addition of a "hardener," say, copper, reduces the elongation of aluminium. An aluminium alloy, containing 12 per cent. of copper, will show less elongation than an alloy containing only 6 per cent. of copper when testing it at normal temperatures. Nevertheless, the 12 per cent. copper alloy has a greater elongation at high temperatures than the 6 per cent., and consequently the 12 per cent. alloy is better able to withstand the casting stresses to which it is subject in the die-casting process.

The zinc-base alloys are not suitable for casting in metal moulds (especially if commercial spelter is used)—for, as previously pointed out, it absorbs iron from the moulds, shows a striking tendency to hot-shortness, and subsequent cracks on cooling, due to lack of "give" in the metal moulds as compared with sand moulds. An alloy of 92 per cent. aluminium and 7 per cent. copper and 1 per cent. of manganese gives very good results for die-casting under pressure, since this alloy sets forth a practical compromise between the antagonistic requirements of low melting point, high tensile strength and ductibility at temperatures just below the point of solidification.

Die-Casting.—The metal is melted in the furnace crucible and the temperature of the furnace regulated by means of a pyrometric installation, so that the alloy is kept at a uniform temperature

about 10 deg. C. above the melting point of the alloy.

The assembled dies are heated to about 260 deg. C. and fixed over the nozzle of the machine. The sprue-cutting bar is released back, thus opening the nozzle, and the metal molten is forced into the dies.

When the mould is full the sprue-cutting bar is brought to position, thereby cutting off the supply of metal. The die is opened, the casting removed, the die re-assembled, and the operations are repeated.

The dies should be lubricated now and then, in order to facilitate the removal of the casting and to protect the die surfaces; a mixture of lard, oil, beeswax and graphite is used for this purpose.

Some Difficulties in the Manufacture of Malleable Iron Castings.

It is generally acknowledged that in no other branch of iron-foundry practice is there needed so much skill and care to overcome difficulties as in the making of malleable castings. This is because the process of making malleable castings divides itself into two distinct sections, the actual casting, and the annealing, and the success of the entire procedure equally depends upon both sections.

A malleable casting, if taken as cast, is extremely hard and brittle, but after annealing it should be soft and ductile, comparable indeed with a mild steel. There is usually no difficulty in obtaining castings which are hard and brittle; the difficulty being that the annealed castings very often remain unchanged. This difficulty may arise from faulty annealing, but is much more likely to be caused by the bad composition of the original metal. Since there are so many possible faults only one or two of the more common defects will be dealt with. Probably the first serious difficulty is the obtaining, in the annealed casting, of a decarbonised soft rim, associated with a hard, white, brittle, and coarsely crystalline interior, which resembles the original hard casting. This defect usually results from the use of metal containing either low silicon, high sulphur, or both.

In normal practice it has been found that this structure occurs in castings containing 0.4 per cent. silicon and 0.3 per cent. sulphur, and if either the silicon is lower or the sulphur is higher the probability of such a result appearing is increased. It should be noted that if such castings are annealed for a time, sufficient to decarbonise them complete, then a very soft and malleable casting is the result, but only arrived at by an exorbitant expenditure of fuel.

Another difficulty often encountered is that thick castings are found to be soft, but not malleable—that is, a test bar cut from a thick casting has little or no elongation. The cause of this defect usually lies in the sulphur content. It must be remembered that, in thick castings, it is scarcely possible to decarbonise properly, since the time which would be necessary to remove the carbon from, say, a 1 in. section, would be so long as to place it beyond the bounds of practice. Consequently it is necessary to make castings of such a composition that as much carbon as possible is precipitated as "temper" graphite. If the silicon is low or the sulphur high, no graphite is precipitated, and a structure having a hard, white centre is obtained. If the silicon is about 0.7 per cent. some graphite is certain to be precipitated during annealing, and the amount formed is controlled by the sulphur content, which, if high, sufficient combined carbon will be left to render the castings brittle, but yet they will be sufficiently soft to drill or machine with ease. A sulphur content of 0.3 per cent. will produce such a condition.

The remedy may be one of several. The silicon can be raised till the castings, almost, but do not quite, precipitate graphite after casting. The sulphur may be lowered to such an extent that no combined carbon is found in the castings after annealing, or the castings may be completely decarbonised by prolonged annealing. Sulphur reduction, to an extent sufficient for "Black-Heart" work, is scarcely practicable in a cupola, but the less sulphur in the casting the nearer will the product approach to Black Heart and the more malleable it will be.

Thin castings are sometimes annealed together with thick castings, and it is found that whilst the thicker castings are satisfactory, the thinner ones are very brittle. This is because the thin work has been completely decarbonised and internally oxidised, whilst the thicker work has only just become decarbonised during the same period. The remedy is either to sacrifice some malleability in the thick castings and anneal for a shorter period, or to separate the different sections and anneal each lot for a different period, depending on its average thickness.

Another difficulty is the peeling of castings during annealing, which is generally caused by too high a temperature. If a temperature of 950 deg. C. is exceeded, this trouble is likely to occur. Thin castings annealed at such a heat are especially liable to become "rotten." If it is found that castings cannot be annealed in a reasonable time, at or below this temperature, then it may be taken for granted that something is radically wrong with the composition of the melt.

In conclusion, all troubles should be treated on their own merits, or rather demerits, and full advantage taken of the use of analysis, the microscope, the pyrometer, and the testing machine.

USES OF METALLIC CADMIUM.—Mr. H. R. Hanley, in a recent issue of the "Chemical Trade Journal and Chemical Engineer," states that the low melting-point of cadmium renders it useful in the production of low melting-point alloys used in the manufacture of fusible plugs in sprinkler systems designed for fire protection. United States patent 89743, September, 1908, by Enrique Touceda, describes certain mixtures containing lead and cadmium. This inventor advocates the following mixtures for bearings :—

	Pb.	Cd.
For cheap work and light loads ...	97.25	2.75
For general and ordinary work ...	92.00	8.00
For bearings subject to shock ...	89.00	11.00
For armature pin ends	86.00	14.00
For extremely severe loads ...	82.00	18.00

Professor Touceda states that hardness and fine grain are obtained by the use of lead-cadmium alloy. Other anti-friction cadmium alloys were used by this inventor, involving magnesium, mercury, and bismuth. Claims were made that magnesium hardens the alloy without destroying the ductility produced by the cadmium. Mixtures of the following compositions were cited : (1) Pb 85, Cd 10, and Mg. 0.1 to 5 parts; and (2) Hg 5.3, Bi 5, and Cd 42 parts. It is now known that the Germans used solders with 10 per cent. Cd and 10 per cent. Sn, and the cadmium content in other solders ranged as high as 30 per cent. Cd, with 2 per cent. Sn. It is further cited that cadmium is a better rust preventive than nickel. A cadmium band fitted to a projectile is said to take the rifling with little wear.

AMERICAN WAGE REDUCTIONS. — Though a general wage reduction was anticipated in the iron and steel industry in the Mahoning Valley, effective January 1, it failed to materialise. The most drastic curtailment in the Valley has been made by the Trumbull Steel Company, which has reduced its forces to minimum, and is evidently preparing for a somewhat protracted period of curtailed operations. Many positions have been abolished, while stenographic and clerical help has been greatly reduced. The Pullman Company reduced wages 20 per cent. at its car manufacturing plant, Pullman, Ill., effective January 1. Also on this date the William B. Pollock Company, of Youngstown, Ohio, instituted a five-day week at its works, and abolished overtime wages, hitherto paid at the rate of time and a half for all over eight hours. Usual working shifts will be maintained. The United States Cast Iron Pipe and Foundry Company, Burlington, N.J., has announced a wage reduction of 20 per cent. at its local plant. The Bethlehem Steel Company has announced a reduction of wages at the South Bethlehem plant of from 10 to 20 per cent., effective January 16. The announcement was made following a joint meeting of the company officials and representatives of the workmen under the employee representation plan in effect at the plant. The reduction is similar to the one being made at the Lebanon plant. A 10 to 20 per cent. reduction is also announced for the Sparrows Point plant effective on the same date. The company employs from 5,000 to 6,000 men under normal conditions. This force has been slightly reduced in the past few weeks.

XUM

Standardisation in the Testing of Welds.*

By F. M. Farmer, of the American Bureau of Welding, New York.

Welding by gas and electrical means has long since passed the stage of small applications, and is becoming one of the more important of the arts employed in the manufacturing of metallic structures.

No argument is needed for standardisation as a general policy. Its value in most fields of human activity, and particularly in engineering, is generally acknowledged. Therefore, when a new art becomes an important element in industry, standardisation is not only desirable, but is almost essential if development along sound engineering lines is to continue.

Need for Standardisation in Testing Welds.—The great need in welding is for some standardised method of measuring or determining the relative value of a weld. The ideal weld is presumably one which does not change the characteristics of a structure containing such a joint from those which the structure would have, if no joint had been necessary. In other words, the joint should have the same characteristics as the adjoining metal. If this view be correct, what tests should be made to determine these characteristics, and how is the degree of approximation of a weld to the ideal weld to be determined?

Standards for Testing Welds.

Fundamental Basis.—A weld is, in general, made for the purpose of joining together two pieces of metal in a structure. Joints are usually a necessary evil. They are avoided when it is possible to fabricate structures without them. The effectiveness of a joint is therefore determined by a comparison of the characteristics of that part of a structure containing the joint with a similar part which has no joint.

Types of Standards.—It is obvious that for many purposes an investigation of a weld need not be extensive. There should be, therefore, several standards which will serve the more usual purposes. Three standards are suggested—shop standard, commercial standard, and research standard.

(*a*) *Shop Standard for Testing Welds.*—In the shop a standard test is required for such purposes as checking the work of a welder from time to time, testing a new lot of electrodes in electric welding or of welding wire in gas-welding, testing the effect of some change in conditions which may have taken place, etc. Such a standard must necessarily be as simple as possible, and preferably a single test. The technique of the procedure in making the test must be of a simple character. For such a standard a bending test is suggested. A bending test involves more of the important properties of a material than any other single static test, yields the most information, and can be made with very simple apparatus.

(*b*) *Commercial Standard for Testing Welds.*—There are many cases where more than one kind of test should be made, but where the circumstances do not justify a complete investigation. There is, therefore, a need for what might be termed a commercial standard for making, for example, comparisons between different commercial welding processes or between different kinds of electrodes in electric metal arc-welding or different wires in gas-welding. It is suggested that such a standard consists of three tests—a bending test, a tensile test, and a fatigue test. These three tests probably give more information than any other three tests that could be selected.

(*c*) *Research Standard for Testing Welds.*—When a complete investigation of a weld is to be made for research or other purposes, all tests and examinations are made which will contribute any information in regard to the characteristics of the weld. It may be necessary to make tests of a special character in special kinds of welds or where application under unusual conditions is contemplated, but there should be a standard list of tests which will give information which is complete, as far as all ordinary requirements are concerned. The following is suggested for such a standard list:—

A.—*Tests of Base or Parent Metal.*—(1) Chemical analysis; to include carbon, manganese, silicon, phosphorus, and sulphur. (2) Mechanical Tests: (*a*) Tensile; to include yield-point, ultimate strength, total elongation, and reduction of area. (*b*) Bending. (*c*) Fatigue. (3) Metallographic. Photomicrographs at 100 diameters.

B.—*Test of Weld.*—(1) Mechanical Tests: (*a*) Tensile; to include yield-point, ultimate strength, total elongation, and reduction of area. (*b*) Bending. (*c*) Fatigue. (*d*) Impact. (2) Metallographic. Photomicrographs at 100 diameters at (*a*) the junction between the base metal and the filled-in metal, (*b*) the base metal adjacent to the junction, (*c*) the centre of the filled-in metal.

C.—*Tests of Filled-in Metal.*—(1) Chemical analysis; to include carbon, manganese, silicon, phosphorus, and sulphur. (2) Mechanical Tests: Standard round specimens to be prepared from ingots deposited in a base-metal mould of such dimensions that normal cooling conditions will be approximated. (*a*) Tensile to include yield-point, ultimate strength, total elongation, and reduction of area. (*b*) Bending. (*c*) Fatigue. (3) Metallographic: Photomicrographs at 100 diameters.

Numerical Evaluation of Welds.—The evaluation of articles manufactured in quantity is usually determined by comparison with a standard of some kind. Where a number of variable properties or characteristics are involved, the most reliable evaluation is obtained by employing a numerical method. For example, each property is compared with the corresponding property of the standard and a percentage value assigned. Where such comparison cannot be made by actual measurement, a value is assigned which is based on judgment. If all of the properties are of equal importance, the final evaluation figure is simply the average of the various percentages. In general, however, certain properties are more important than others, and should therefore be weighted before averaging.

In the case of welds, most of the characteristics are determined by test and expressed in a numerical result. The standard is usually the base metal, so that an evaluation of each characteristic of the weld in per cent. of that of the standard is easily made. The principal difficulty is in selecting the weights to be used when averaging for the purpose of assigning a value for the weld as a whole.

In the "shop standard" proposed, only one test is made so that evaluation is obtained directly. In the "commercial standard" three tests are made, the relative value of the results of which will depend upon the purpose of the investigation. If, for example, it is for the purpose of testing the applicability of welding to structures where the stresses are low but vibration is always present, the result of fatigue tests is of great importance. On the other hand, if the structure is a large tank for liquids, the fatigue test result is not as important as that of the tensile test and the bending test.

It is suggested that for general purposes the "commercial standard" be evaluated by weighting the tensile and fatigue tests by 1 and the bending test by 2.

Standard Procedure in Mechanical Tests of Welds.

Of the three kinds of tests which are made for the purpose of investigating a weld, mechanical tests are the most important and are in the greatest need of standardisation, because they yield information about those characteristics which are of greatest significance in the majority of applications of welding. Furthermore, they are the most easily made, are better understood by a larger proportion of those interested in welding, and the results are more readily interpreted.

Tensile, bending (transverse), torsion, impact, and fatigue may be made on specimens cut from a sample weld, but tensile, bending, and fatigue tests will give ample data for all ordinary purposes. The impact test undoubtedly has much value in connection with certain applications of

* Extract from a Paper recently read before the Institution of Mechanical Engineers.

welding, but it is questionable if a static torsion test develops any information that is not obtained from a tensile and a bending test. A standardised procedure is therefore particularly needed for tensile, bending, and fatigue tests. The procedures outlined in the following paragraphs have been used in a large amount of testing work and have been discussed to some extent for standards. It is believed by the author that standarisation along the general lines indicated will be in the right direction.

Tensile Tests.—Standardisation along new lines should utilise existing standards as far as possible. The standard test specimen in America for rolled or sheet material is that of the American Society for Testing Materials, and is shown in Fig. 1. It has been suggested that tensile specimens from test welds be of the same shape and dimensions.

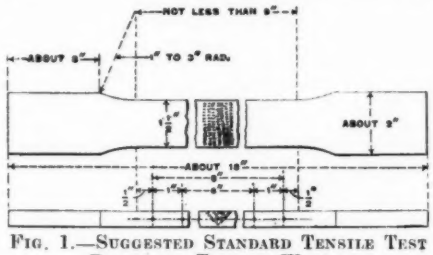


FIG. 1.—SUGGESTED STANDARD TENSILE TEST PIECE FOR TESTING WELDS.

In some kinds of welding the test weld will not be flat, and in such cases the wide sides of tensile specimens should be at least rough-machined in order to ensure parallel sides. In any case, excess metal at the weld should be removed, so that the cross-section area throughout the reduced section is constant.

Gauge marks should be laid off along the centre lines of both edges 1 in. apart, as shown in Fig. 1, the weld to be at the centre of the middle inch. The corresponding points on the edges should be in the same straight line perpendicular to the lengthwise axis of the specimen.

The results should include the yield point and ultimate strength expressed in lbs. per sq. in. of the original area; total elongation after rupture in 1 in., 2 in., and 8 in., expressed in per cent., each of the measured results as well as the average of corresponding results to be recorded; contraction of area in per cent. The usual notes on the character of the fracture should be recorded, including comments on the extent of gas pockets, slag inclusions, or incomplete fusion which may be shown.

Bending Tests.—Of all the tests that are made on welds, none requires standardisation more than the bending test, because it is of an arbitrary character, and there is therefore a wide divergence in the details of procedure. The result of a bending test is usually expressed as the angle through which the specimen can be bent when the first fracture appears, but this angle is obviously greatly affected by (*a*) the radius of curvature of the supports, (*b*) the shape and dimensions of the loading surface, (*c*) the distance between the supports, (*d*) the method used in measuring the angle.

Anyone who has made bending tests of welds will agree that all of these conditions influence the results, and where they differ it is impossible to make comparisons which have any value. Reference to results of tests of base or parent metal obtained with the same apparatus does not eliminate the difficulty, because many parent metals —mild steel, for example—will bend to the limit of 180 deg. over a wide range of the conditions enumerated above. It is therefore absolutely necessary to have a carefully standardised bending test procedure before bending tests of welds can be compared.

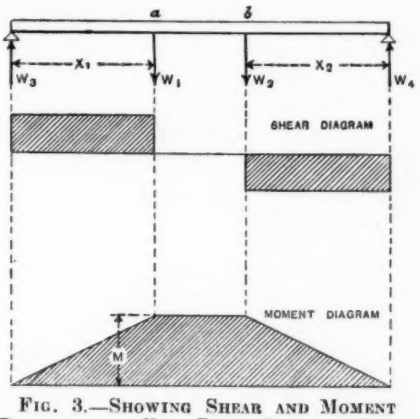


FIG. 3.—SHOWING SHEAR AND MOMENT DIAGRAM OF A FOUR-POINT ROTATING BEAM.

The bending test fixture shown in Fig. 2 has proved very satisfactory, and is one in which the features mentioned above can be readily standardised. It will be seen that the specimen is tested as a simple beam with a minimum distance between the supports and with the weld at the centre, the load being applied at the centre of the weld. Such an arrangement assures a severe test of the weld, because the joint is a maximum part of that portion of the specimen which is between the supports. The fixture is conveniently constructed if two pieces of steel rail are used for the supports, with suitable provision for adjusting the spacing to accommodate various thicknesses of specimens.

The following are the essential dimensions :—
D = diameter of cylindrical loading surface =

FIG. 2.—SHOWING SUGGESTED STANDARD BEND-TEST FOR TESTING WELDS.

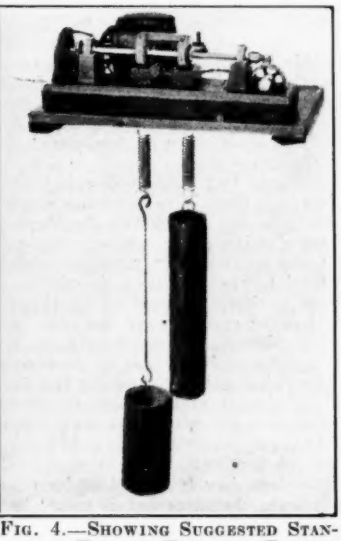


FIG. 4.—SHOWING SUGGESTED STANDARD FATIGUE TEST FOR TESTING WELDS.

thickness of test specimen, t; R = radius of corners of supports = 1 in.; W = distance between supports = D + 2t + $\frac{1}{8}$ in.

The top surfaces and corners of the supports are polished and lubricated with a heavy lubricant. In the case of a weld made with metal deposited in a "V," the specimen is always tested with the load applied to the side of the specimen which shows the least filled-in metal. The fixture can be conveniently used with a standard testing machine of the vertical type, but a simple, self-contained structure for applying the load can be readily constructed.

The quantity measured in the test is the *total* angle through which the specimen is bent at the instant the first crack appears in the specimen. As the test is usually made with the load applied in a vertical direction and on top of the specimen, it will be found convenient to view the under surface of the specimen by means of a mirror and an electric lamp suitably located.

The angle of bend can be quickly measured by the simple method shown in Fig. 2. The outline of the upper edge of the specimen is marked on a sheet of paper held against the edge of the specimen (before the load is removed), and the angle measured with an ordinary protractor. As the specimen may not have been perfectly straight initially, a similar procedure should be followed before the load is applied. The difference between the two angles is the angle of bend which the specimen withstood, and is compared with the similar angle for a similar test of a specimen of the base metal. The width and length of the specimen may be any convenient values as far as the test itself is concerned. A width of 1.5 in. and a length of 6 in. have been found convenient for ordinary thicknesses of material. It is obvious that if the test is made with an ordinary testing machine the fibre stress can be calculated by the standard flexure formula for a simple beam supported at the ends and loaded at the centre.

Fatigue Tests.—The fatigue test is of great importance in an investigation of welds, particularly those which are to be used in structures in which rapidly varying stresses exist, such as ship hulls, building structures, and machinery. It has long been recognised that the usual static tests do not necessarily furnish information from which the performance of a material under a long-continued variable stress can be predicted. It is desirable to know the effect of any type of joint in a structural member on the fatigue strength of that member. With a welded joint the question becomes particularly important because of the introduction of more or less metal of a different character.

A fatigue test, like a bending test, is largely arbitrary. That is to say, the result obtained is an abstract one, which has significance only when compared with other results obtained in exactly the same manner. In the case of tests of welds, the final answer is the ratio of the result of the test of a specimen containing the weld to that of a similar specimen of the base metal. Consequently, the exact method of procedure employed may not be as important as in the bending test, for example, provided the same test is made on both weld specimens and base-metal specimens. However, experience may show that this ratio is not reliable, for example, over a wide range of thicknesses of material, so that standardisation of a fatigue test may be found to be necessary, quite apart from the fact that it would be desirable on general grounds.

A welded joint is not a homogeneous structure, for it not only consists of different materials, but in the case of a "V" weld the area of cross-section of the filled-in metal varies throughout the joint because of the "V" shape of the filled-in metal and the irregularity of the line of union between the filled-in metal and the original metal. It is highly desirable, therefore, that the type of fatigue test employed for welds be one in which a uniform stress is developed throughout that part of the test specimen in which the weld is located.

A fatigue testing machine in which this condition exists was developed for the Research Sub-Committee of the Welding Committee of the American Emergency Fleet Corporation.

The principle employed is that of a four-point rotating beam, with two free supports at the ends and two loads at the middle. Fig. 3 shows the familiar shear and moment diagrams for a beam so loaded in which $W_1 = W_2 = W_3 = W_4 = W$ and $X_1 = X_2 = X$. The moment between a and b is uniform, and has the maximum value of WX. If the beam has a uniform circular section the maximum fibre stress in all sections between a and b is

$$S = \frac{Mc}{I} = \frac{WX}{0{\cdot}0982\,d^3}$$

in which S = stress in outer fibre in lbs. per sq. in., M = bending moment in inch-lbs., c = distance from neutral axis to outer fibre in inches (= d/2), I = moment of inertia, W = load in lbs., X = distance between loads and supports in inches, and d = diameter of beam in inches. The beam is in tension on the lower side and in compression on the upper side. Thus, if a circular rod is turned from a specimen cut from a weld, loaded in the manner indicated above with the joint in the middle, and then rotated, the joint will be subjected to a maximum stress equal to S alternately in tension and compression once per revolution.

Fig. 4 is a photograph of a machine for specimens from welds in $\frac{1}{4}$-in. material. The specimen is carried by four self-aligning ball bearings; the two end bearings rest in the pillow blocks, the whole being supported on a cast-iron base 5 in. by 19$\frac{1}{4}$ in. One of the pillow blocks provides for longitudinal movement of the bearing, due to the slight bending of the specimen. The two equal loads are hung from hooks attached to collars which encircle the outer races of the two middle bearings.

The bearings are securely fastened at the proper position by means of two split collets of carburised steel with opposite tapers, one entering from each end of the bearing. This produces a wedge action which gives a uniform pressure over the entire bearing surface on the shaft, and ensures the validity of the assumption that the point of application of the loading forces is at the centre of the bearings. The inner collet is counter-bored as shown, so that the bearing surface on the specimen is as short as possible. The collects are wedged together by a nut on a thread on the inner collet, and are loosened with the aid of a wedge-key driven under the head of the inner collet.

The specimen is rotated through the loose coupling at one end of the specimen, and the revolutions are counted by a suitable counter geared to a worm on the other end of the specimen. These various fittings are most conveniently put in position on the specimen at a vice on a bench. The specimen with the fittings in position is then dropped in position in the machine, the weights hung on to the hooks (with spiral springs intervening), and it is ready to be rotated.

When failure occurs, the specimen will stop rotating because it "binds," and the belt will either slip or be thrown off. However, the preferable way for securing automatic stopping is to provide a simple switch arrangement which will be operated by one of the weights when it drops; this will cut off the motor.

This particular machine was designed for specimens from welds in $\frac{1}{4}$-in. plates, but obviously a machine could be constructed for specimens of any ordinary diameter. A machine could be constructed with a longer base for specimens from $\frac{3}{8}$-in. to 1-in. plate by providing bushings of suitable sizes and arranging for changing the distance between the supporting pillow blocks, so that the weight can be kept within reasonable limits.

The standard specimen for the machine described is 13 in. long and 0.4 in. in diameter throughout its entire length. This diameter is about the maximum that can be turned out of a specimen cut across a weld in $\frac{1}{4}$-in. material, which is rarely perfectly straight. Care is taken that the diameter in the middle portion where the weld is located is exact, and that this part of the specimen is carefully finished free from tool marks or scratches.

The criterion of the performance of a joint of any kind is the performance of a similar specimen of the original metal without a joint. Consequently, fatigue tests of welds in $\frac{1}{4}$-in. plate are compared with tests made with the same apparatus and at the same stress on specimens from the original plate. When such tests were made with

specimens of constant diameter throughout their length failure always occurred at one of the load bearings, and not between them, as is the case with weld specimens, where the joint is usually the weakest part of the specimen. It is believed that this is due to the sudden change in the stress distribution (Fig. 3) at these points, and probably also to the radial compressive stress induced at these points by the loads. By reducing the diameter between these points and using long fillets, failure will occur in the central portion of the specimen and the true endurance value of the metal will be obtained.

The objection might be made that the specimen is too small to give reliable information about what a weld of any considerable length would do, unless a number of specimens were cut along the weld. The answer is that the very fact that the small specimens require a number of tests to be made is an advantage, because definite knowledge of the uniformity of the strength (or lack of it) along a long weld is very important, and obviously this would not be obtained with a single wide specimen.

Number of Specimens that should be Tested.—A property which is most important in a weld is uniformity. It is therefore desirable to subject a number of specimens to each of the various mechanical tests. A separate sample or test weld can be prepared for each specimen, but in electric arc welding in particular this means greatly increased expense in metal, in making the welds, and in machine work involved in preparing the test-specimens because of the necessity for cutting away enough of the edges to eliminate the beginning and ending of the weld. In electric arc welding at least it is more economical to make one large test weld, and cut it up into the pieces from the which the test-specimens are machined. In gas welding a skilled workman may be capable of making a finished weld right up to the ends of the weld, in which case making each test-specimen separately might be more economical. But the method of making one large weld has the further advantage that it more nearly duplicates the usual practical conditions—that is, long joints, with the attendant temperature effects as determined by adjacent relatively large masses of metal.

Not less than three specimens should be subjected to each of the mechanical tests. They should be cut from the test weld in such a manner that one specimen for each test is cut from the middle and one near each end, enough of the edges being first removed to eliminate defective welding which may exist at the beginning and end of a weld.

Elongation Data in Tensile Tests.—Elongation measurements on weld specimens are of limited value. The specimen is not homogeneous throughout its length, and unless the ductility of the filled-in metal of the joint is the same as that of the base metal, the result obtained is a composite of the ductility of the filled-in metal and the base metal. Such measurements have some value, however, when comparing welds of the same class with the same base metal. In a thorough investigation of a weld of the deposited-metal type, data on the ductility of the filled-in metal itself should be obtained by making tests of specimens consisting of filled-in metal only.

Width and Gauge Length in Tensile Tests.—The use of a specimen of constant width and gauge length, irrespective of thickness, might be questioned on the ground that it disregards Barba's law of proportionality, which states that the ratio of the gauge length to the square root of the area should be a constant. Investigations made by Professor H. F. Moore, under the auspices of the Committee on "Methods of Testing" of the American Society for Testing Materials, showed that varying values of this ratio (within reasonable limits) do not affect the yield point, elastic limit, reduction of area, or the tensile strength (of specimens of homogeneous material), but that there is a marked effect on the elongation.

So far as elongation data in tensile tests of welds are concerned, it has already been pointed out that such data are of limited value. This being the case, it does not appear that in ordinary tests of welds the additional complication involved in following standard dimensions based on Barba's law would be justified. But where investigations are being made to determine the effect of thickness on the weld it may very well be advisable to follow this law. In that case it would appear desirable to make the gauge length as short as possible, and such that the ratio of the filled-in metal to the base metal within the gauge marks is a constant. Then the width should be varied to keep the ratio $\frac{L}{\sqrt{a}}$ a constant for the various thicknesses. Obviously, the tests of base metal which would be made for reference should be made on specimens of corresponding shape.

Standard Stress Value in Fatigue Tests.—In the fatigue tests made for the Research Committee of the Emergency Fleet Corporation a standard maximum fibre stress of 25,000 lbs. per sq. in. was employed in testing of weld specimens and the corresponding specimens of base metal. The selection of this value was based on the following considerations. The characteristic which it is desired to test is the elastic property under reversed stress conditions, and not ductility, since in practice a material is never intentionally stressed above the elastic limit. This means, therefore, that the stress should be below the elastic limit, because the relative performance of materials in a fatigue test will probably be very different above the elastic limit, where the property involved is ductility, than it will be below the elastic limit, where elasticity is the property involved. On the other hand, the higher the stress the more quickly results will be obtained. As there is no reason to suppose that the relative behaviour of different materials will not be the same at low stresses as at high stresses (provided they are below the elastic limit), a stress of 25,000 lbs. was adopted. This is as close to the elastic limit of ship-plate steel as it was thought advisable to go.

Inspection and Tests of Welds in Structures.—The phase of the welding art which is in greatest need of standardisation is that of inspection and testing of completed welds in commercial applications. But progress towards this desirable end can hardly be expected before a satisfactory and commercially practicable method of determining the quality of a weld in a structure is devised. Investigations of various suggested methods of testing completed welds were made by the Welding Committee of the Emergency Fleet Corporation. These included X-ray examination, determination of the electrical resistance by a method somewhat similar to that employed in testing rail-joints in electric railways, hammering and chipping of the weld and magnetic examination. None of these offered definite promise of success at the termination of the Committee's activities. In certain limited fields of application, satisfactory tests may be devised, such, for example, as closed vessels which can be subjected to hydraulic pressure and simultaneous hammering after completion. Possibly also some method will be devised for removing a test-specimen which can be readily tested, the hole being small enough to be filled up easily.

But at the present time the only checks on the quality of the welder's work in general applications which are available appear to be (*a*) confidence in the welder's proficiency and his integrity, and (*b*) systematic inspection *during* the progress of the work. Even here standardisation may be applied advantageously. That is, we should have (*a*) a standardised test of proficiency of welders or perhaps several standards for different grades of welders, and (*b*), a standardised procedure for the inspection of various kinds of welds while being made. Standardisation of this kind should have the added value of aiding in obtaining the confidence of those authorities whose approval is necessary before welding can be applied in a number of important fields.

REVIVAL OF THE BELGIAN IRON AND STEEL INDUSTRY.—The situation of Belgian blast furnaces with their production, compared to that of 1913, is given as under in a recent issue of the "Journal de Liège":—The average daily production of pig for castings has increased 100 per cent. since July 1, 1920, and the production of pig for the manufacture of steel has increased by over 22 per cent. since that date. Four further blast furnaces have been re-lit since the date mentioned. —"Board of Trade Journal."

Institution of British Foundrymen.

COVENTRY BRANCH.

At a joint meeting of the Coventry Branch of the Institution of British Foundrymen and the Coventry Engineering Society, held in the Technical Institute, Coventry, on January 28, Mr. C. M. Walter, D.Sc., A.M.I.E.E., gave a lecture on "Thermometry and Pyrometry, as Applied to Industrial Operations."

Mr. E. A. Watson, Vice-President of the Engineering Society, presided.

The Chairman, introducing the lecturer, said Dr. Walter, who was head of the Industrial Research Laboratory of the City of Birmingham, had done a great deal of work for the manufacturers of the Midlands, particularly of Birmingham. He had done also much work in pyrometry, a subject of much practical interest to many people in Coventry.

Thermometry and Pyrometry in Industrial Operations.

The lecturer gave a comprehensive account of the origin and development of the various instruments used for the measuring of heat, showing limelight views illustrating the instruments and their method of application.

The investigations of eminent scientists since the days of Galileo in regard to the measurement of temperature had now enabled that work to be done with great accuracy, even under the conditions met with in works practice.

In a concise historical survey, Dr. Walter attributed to Galileo the earliest form of thermometer, consisting of a glass bulb with narrow tube attached, the bulb containing air and the narrow tube alcohol.

Sir Isaac Newton was the first to attempt to measure the temperature of a fire by observing the time taken to cool a bar of iron withdrawn from it. Later, in 1782, Josiah Wedgwood, the famous potter, made use of the contraction of clay when baked at different temperatures as a means of controlling the temperature of his furnaces. In 1822 several types of expansion thermometers were devised, and in the same year Seebeck discovered the existence of the thermo-electric effects produced in a closed circuit composed of two dissimilar metals with their junctions at different temperatures and at a later date Becquerel proposed making use of the thermo-e.m.f. so produced as a means of measuring temperatures. The further researches of Le Chatelier on the possibilities of this method of measuring temperatures, published in 1886, firmly established the thermo-electrical thermometer as a practical instrument, and at the same time marked a great advance in the progress of pyrometry. That method was now extensively used in practice. About this time the researches of Callender and Griffiths with regard to the variations of electrical resistance of platinum wire with changes of temperatures led to the evolution of the platinum scale of temperature and eventually to the platinum resistance thermometer in its present form.

The possibility of deducing temperature of bodies from the intensity of the luminous radiations emitted resulted in the Le Chatelier optical pyrometer successfully developed in 1892.

Later, in 1902, Professor Féry invented another valuable instrument for measuring temperatures based on the Stefan Boltzman fourth power radiation law, and depending for its operation on the heat radiations emitted by hot bodies. The Féry radiation pyrometer has proved of extreme value and has since been developed as a works instrument.

Since that time much valuable work has been done by such firms as the Cambridge and Paul Instrument Company, Limited, Mr. R. W. Paul, the Foster Instrument Company, and other well known firms in the development of the various types of thermometers and pyrometers to render them suitable for practical applications.

The lecturer then described in detail the principal instruments in use and the principles of their operations. These details have, however, been previously published by the Foundry Trade Journal in a report of a former paper by Dr. Walter.

The latter part of the lecture was devoted to an examination of the latest types of appliance, some of which were used by Dr. Walter in connection with his daily work. For example, he mentioned that where the total radiations, that is both luminous and non-luminous radiations, are made use of he used a total radiation type of instrument in which the heat radiations were brought to a focus by means of a concave mirror at a point where a small very sensitive thermo-couple was arranged. The heat radiations were thus caused to heat up this thermo-couple which connected in the ordinary way with some form of galvanometer. Notable types of instrument coming under this head were (1) the Féry radiation pyrometer made by the Cambridge Scientific Company, and (2) the Foster Fixed Focus Radiation pyrometer.

Attention was also called to the calorimetric pyrometers which depend on the total heat stored up by a small metal article usually in the form of a cylinder, which is placed in a zone whose temperature has to be measured, and after being heated throughout at that temperature is dropped in the calorimeter and the temperature of the zone is then obtained by determining the rise of temperature of the water of the calorimeter. The most notable instrument coming under this head is the Siemens calorimetric pyrometer.

Fusion pyrometers depended on the relative fusibility of various classes of salts and ceramic bodies. Notable examples of these were the Segar cone, thermoscopes, and sentinels, and the Watkins heat recorders. The Segar cone is used very largely for the measurements of high temperatures in the firing of ceramic ware. Sentinels are used very extensively in connection with the heat treatment of metals, and have been found in some instances to be correct to within 2 deg. C. Other forms, such as thermoscopes and sentinels, are also largely used for such operations as the annealing and heat treatment of metals.

In conclusion, the author referred to one or two forms of pyrometers which have been put on the market during the last few years. Reference was made to the pyromike, a handy little instrument produced by Rudge Whitworth & Company, and which depends for its working on a small glass cylinder containing liquid, which can be altered in length so as to absorb more or less of the total light reductions. It is so arranged that the adjustment is made until the luminosity of the object just disappears, when the corresponding temperature is read off on a scale attached to the instrument.

Reference was also made to the wedge and other similar forms of instruments which depend on either colour matching or the employment of absorbing screens.

Discussion.

Following the lecture a conversational discussion followed in which a number of points were raised to which Dr. Walter subsequently replied.

The Chairman mentioned that he had had experience with pyrometers of the Northrup type, and could testify to the accuracy of those instruments.

Dr. Walter, in his reply, remarked that he had had some experience of instruments similar to the Northup type, which he understood depended on colour matching, the luminous radiations from a heated body being viewed together with those from a standard light consisting of an electric lamp, the latter being varied until a perfect match was obtained.

In answer to remarks made by Mr. Griffiths in reference to the variations in the E.M.F. with increase and decrease of temperatures for certain thermo-elements, Dr. Walter said it was quite unusual to find any disturbing effects of this kind except in the case of base metal couples where carbon was present to any extent in the iron element. It was generally usual to employ very low-carbon steel-wire for such elements, but if the carbon was a little on the high side, disturbing effects due to the change point would be certainly noticeable.

As to the pyromike, that instrument depended on the absorption of the luminous rays by means of a collapsible cell containing liquid. Whilst this

form of instrument, together with those depending on colour screens, served a very useful purpose, he thought they should not be looked upon as very accurate instruments.

A point had been raised by Mr. Manley in reference to the use of a thermos flask for maintaining the cold junction at a uniform temperature. Dr. Walter remarked that whilst it was not possible to maintain the temperature of the cold junction absolutely constant by these means, nevertheless, the variations which took place compared with what might be expected of the cold junction in atmosphere were very small indeed. The main object was to maintain the cold junction by some definite constant temperature.

Replying to some remarks by Mr. Brandish, the lecturer said that the period during which any particular thermo-couple would retain its accuracy within specified limits depended largely upon the protection afforded, and the working temperature. Generally speaking, pyrometers using platinum and platinum-rhodium elements would retain their accuracy for a period of twelve months at least if proper protection was arranged for and the working temperature did not exceed, say, 1,000 deg. C. to 1,100 deg. C.

Referring to some remarks as to a suggested simple check for works pyrometers, Dr. Walter said a very simple check could be carried out by taking the freezing point of common salt, the salt being first heated up in the pot and then allowed to cool slowly. From the cooling curve, it would be found that the freezing point was generally between 800 deg. C. and 801 deg. C. This constituted a simple and inexpensive method of checking over one point of the range.

One speaker, Mr. Franklin, remarked Dr. Walter, had found considerable difficulty in checking pyrometers by making use of the freezing point of common salt, owing to the variations which he had found to exist in the melting point. Any such variations, said Dr. Walter, were probably due to impurities present in the salt which would probably account for the raising or lowering of the freezing point found by Mr. Franklin. If an instrument had been accurately calibrated in the first place, one point on the temperature scale was generally considered a sufficient check as to the condition of the instrument. He would suggest that Mr. Franklin should try the cooling curve for pure zinc, the freezing point for which was 419 deg. C. This metal was easily obtained in its pure state, and its freezing point formed a useful fixed point on the temperature scale.

MR. DUDGEON, proposing a vote of thanks to Dr. Walter, expressed appreciation of the very comprehensive display of instruments which had been got together.

MR. LANE, the Secretary of the Coventry Branch, in seconding, thanked the Engineering Society for the invitation to the foundrymen to attend the lecture.

BIRMINGHAM BRANCH.

What is Semi-Steel?

Discussion.

MR. W. FLAVELL, in proposing a vote of thanks, said he would like to ask Mr. Field whether he had had any experience in making rolls of semi-steel. Rolls were cast as a plain barrel, and were turned on the outside. Then grooves had to be cut into the barrel for rolling different sections. In cutting these grooves they reached the more porous grain of the casting and it occurred to him that possibly semi-steel, melted in the air furnace, might be used for making rolls. Possibly it might also be used for plate-rolls, in which too great a chill was not required, but rather a good, close, dense surface.

THE BRANCH-PRESIDENT said that the outstanding feature of the paper was the point raised by Mr. Flavell as to the possibility of utilising semi-steel for making rolls. Roll makers were practically tied down to using high-grade iron. If by using the steel scrap, which was usually lying about works, a low-grade iron could be made to suffice then certainly something advantageous had been brought out. At the earliest possible moment he would make some experiments in that direction. Already a mixture containing 30 per cent. of steel had been tried, but so far had not been used for roll castings. It was found that with such a mixture the tensile strength was raised to between 15 and 16 tons; in fact, physical properties were shown which would have been impossible without that mixture of steel. With regard to melting semi-steel in the air-furnace, he did not think the proposition worth trying, as he instanced by a case where the steel was in rather bulky sections and the metal came out almost exactly as they had put it in. He thought it would be a good thing to make a mixture of 25 per cent. semi-steel in the cupola and then transfer it to the air-furnace. This was done in his own works, which was well equipped with cupolas, and it was found that it materially assisted in getting a proper melt. He thought that with semi-steel so melted they should be able to get practically as good results as they now got with high-class pig-iron.

MR. H. L. REASON said he was impressed with Mr. Field's remark that semi-steel was not more ductile than cast-iron, because he thought there would have been a slight difference. Probably there would be some improvement in the elongation. The tensile strength would be considerably increased, probably by 25 per cent. He did not think that there was need for any special way of introducing the steel; all that was wanted was the usual care. According to Mr. Field's chart, there was no beneficial effect on the physical properties due to annealing.

MR. F. JOHNSON said that some of the properties of this mixture of cast-iron and steel and the differences in properties between it and ordinary cast-iron were difficult to explain. He would like to know whether semi-steel in the mould behaved differently from ordinary grey-iron with regard to shrinkage stresses. Did one get a greater or a smaller number of wasters than with grey iron? The fact that semi-steel castings had a finer grain than ordinary iron castings was very interesting. He took it that Mr. Field had not taken the pouring temperatures, which possibly accounted for the fine grain during his investigations.

MR. A. WARDLE said the term "semi-steel" was a disgusting imposture. It meant passing off as a kind of steel something which had no resemblance to steel. They often got drawings specifying "steel or semi-steel." This showed the ignorance of the originator of the expression, and that ignorance might lead to disastrous results. He thought that the Cast-Iron Research Association should make that point clear and should relegate this so-called semi-steel to its proper place, so that engineers might know that semi-steel was simply an improved cast-iron. A better name, perhaps, would be "purified cast-iron," because the material was nothing more than that. It was very useful for a variety of purposes, inasmuch as by using steel in the mixture they could get cast-iron of a grade which it was almost impossible otherwise to obtain even with the highest grade of pig-iron, and they could get this high grade of cast-iron at a low cost. With regard to Mr. Field's analyses, he would like to ask Mr. Field why in the 10 per cent. steel mixture there should be 0.6 per cent. of manganese, whilst in the 20 per cent. there was 0.7 per cent.? It was curious to find an increase in the percentage of manganese resulting from the use of a higher percentage of a material which in itself contained a smaller proportion of manganese. He thought Mr. Field omitted to state that in making semi-steel it was necessary to add manganese to render the metal better able to retain the carbon. With regard to melting the steel in the cupola, really the steel did not melt. The steel, which should have large areas and thin sections, was subjected to a reducing atmosphere which caused the outer skin, possibly to a depth of 1-16 in., to absorb carbon from the coke and the reducing atmosphere. This lowered the melting point, and that layer melted off, exposing another layer to the same conditions.

MR. A. PARSONS said, with regard to melting semi-steel in the air-furnace, he would like to ask Mr. Field what effect the process would have on the mixture in the charge? They had been told about the steel having a large area exposed to the carburising action of the coke. Would

* For paper see Page 201.

there be anything like that effect in the air-furnace, where the surface of the steel did not come into contact with the combustible material, but only with the flame? The statement that semi-steel had no ductility made him wonder whether it would be suitable material for rolls, because a roll when at work was often subjected to great stress. Having at one time accidentally added steel, the pieces of which were not more than ½ in. thick and about 5 in. wide, to a charge in an air-furnace, they found, when they ran off the fluid cast-iron, the steel was left in the furnace. The only alteration which it had undergone was that the sharp edges were rounded off.

MR. D. WILKINSON said that he was rather surprised to hear that they could not melt steel in the air-furnace, because he had regularly done so. The scrap, as strip not more than ¼ in. thick, would melt readily in the air-furnace, but it should be remembered that the carbon was reduced proportionately, and not as in the cupola, where the steel absorbed carbon by contact with the coke. He saw no difficulty at all in making rolls of semi-steel. He thought Mr. Field would agree with him that deformation in cast-iron increased considerably when steel was added to it. The mixing of steel with iron for casting was known long before the term semi-steel cropped up, and he had had experience for a long time with castings containing 25 per cent. of steel. This mixture resulted in a very great reduction in the number of fractures when it was used for the making of casting boxes. He saw no good reason why everybody should not successfully make semi-steel. If melted hot, there should be no difficulty, and certainly there was a great future before this material. He agreed that the term "semi-steel" was a misnomer, as the material was simply an improved cast-iron. He saw no good reason for so much manganese being used. Ferro-manganese used was apt to cause trouble, even in small quantities, in a charge of iron, on account of unequal dissemination. Undoubtedly a high manganese content in the pig was desirable. In making semi-steel castings a very beneficial effect was obtained by adding a small percentage of aluminium in the ladle.

MR. H. L. REASON said that he believed semi-steel was used largely in the parts of Diesel engines, which had to withstand very high temperatures. The last speaker had made an interesting contribution to the discussion when he spoke of the value of semi-steel for box parts. As to the beneficial effect of adding a very small percentage of aluminium to the charge in the ladle before pouring, he might mention that aluminium was used in the same way with good effect in German silver or white metal, where the greatest difficulty had been experienced in obtaining sound castings.

MR. H. HOLLOWAY, speaking of light castings, said that they all knew that steel had a great contraction, and therefore was more liable to crack in cooling than was ordinary iron. He thought that if it was possible to melt semi-steel in the air-furnace that would be a far better method if the material was going to be of value. They might melt the metal in the cupola and then pour it into the air-furnace. He agreed that the name semi-steel was a misnomer.

MR. J. G. DONSON said that many seemed to be in a quandary as to what was meant by semi-steel. Mr. Harley told the speaker, in reply to a question at Coventry that there was no such material. Others said that the name was a fraud. Now they were told that the material was neither cast iron nor steel. In the transition from pig-iron to steel a material was produced which had properties better than those of best iron. This material had not the properties of what was properly termed steel, but in many respects it was better than cast-iron for a considerable variety of castings in which the higher properties of steel were not required. That, he contended, was a fair description of the material known as "semi-steel."

MR. STARR asked whether consistent chemical results could be obtained from semi-steel, as his experience was that not more than once were the same chemical analysis figures returned. The greatest variable was the sulphur.

MR HARRISON asked whether Mr. Field had any experience of making semi-steel with hematite iron, and, if so, whether he found any difficulty with regard to the high total carbon. He found that when hematite was used it was necessary to add manganese.

The Author's Reply.

MR. FIELD, in reply, said that he did not approve of the name "semi-steel," but for lack of any other name he used that as the name by which it was generally known. The company with which he was associated endeavoured to designate it "high-tensile cast-iron," but as other people were calling the material semi-steel they had to fall into line. In his paper he had pointed out that the material was not in any true sense semi-steel, and that in one important respect, namely, that of ductility, it could lay no claim to being steel. They would remember that he pointed out that there were two classes of semi-steel, one a product of the air-furnace and the other of the cupola. In the air-furnace semi-steel should be added to the liquid pig-scrap. In such semi-steel the carbon was reduced exactly in proportion to the percentage of steel added. His belief was that air-furnace melted material would be superior to cupola-melted, because reduction of the combined carbon should be advantageous. There should be no difficulty in making a mixture with 20 per cent. of steel in the air-furnace. The addition of 10 per cent. of steel in the shank lowered the temperature of the iron, and there was no means of bringing the temperature up again; but in the air-furnace the temperature was being continuously maintained. With regard to semi-steel castings which had been sold as malleable, there was a class of malleable castings in the making of which many firms added percentages of steel, partly with the object of reducing the price. In melting their malleable iron these firms added from 10 to 20 per cent. of steel. This, besides cheapening the castings, brought the phosphorus content down, forming a totally different type of semi-steel. As to the use of semi-steel in making rolls, he had some experience of it in chill, and it was more reliable for giving a uniform chill than was ordinary chill cast-iron—and he took it that the rolls in question were at present made from chill cast-iron. He had found that the shrinkage of semi-steel was slightly higher than with ordinary cast-iron, but that had been found to be an advantage in the making of motor-cylinders. With regard to the manganese in the two mixtures, he stated that the same brand of pig-iron had been used, but he did not say that the same proportions of them had been used. The returned scrap was higher in the lower steel-mixture than in the high steel-mixture. That, he thought, explained the discrepancy. He did not recommend the use of ferro-manganese, as he had never found it necessary, and he was not a believer in adding small portions of anything to large quantities of metal, because of the difficulty of obtaining uniform results. With regard to aluminium, the object of using it was to clear out the oxides, which came to the surface in the form of aluminium oxide and formed a scum.

MR. FIELD, continuing, referred to the remarks of Mr. Parsons as to the size of the steel he used in the furnace, and said that the remarks in the Paper on that point would be applicable only to the size of the steel melted in the cupola. They would not apply to melting in the air-furnace. Cold metal does not give such strong metal as hot, and early casts are often discarded, but when used for box parts this material is better than the ordinary grey-iron. In regard to analysis, he had obtained very consistent results. Inconsistent results used to be obtained, but had been overcome by taking greater care as to the quality of the material, the methods of charging and mixing. He had found, in the case of a three or four ton load taking in 10 cwt. charges, very consistent results in the castings. He had not tried melting steel with hematite iron, because that would be costly, and his object was to reduce the price. The sulphur content certainly looked high on paper, but he had not found it detrimental. In his experience he had found the influence of sulphur to be very much overrated, unless present in abnormal quantities.

Trade Talk.

THE summer meeting of the Institute of Electrical Engineers will take place in Scotland from June 7-10 next.

THE French Government have imposed a duty of 1 fc. 50 cents per 100 kilogs gross on the export of basic slag.

BABCOCK & WILCOX, LIMITED, have acquired a site at Regent's Park, New South Wales, where they propose to establish branch works.

SPEAKING to members of the Sheffield Society of Metallurgical Chemists on February 22, Mr. B. W. Methley took as his subject "Sampling of Raw Materials."

MESSRS. ARMSTRONG, WHITWORTH & COMPANY, LIMITED, deny the report which has appeared to the effect that the firm is about to amalgamate with Vickers, Limited.

OWING to stagnation in the metal market, operations at the mine and smelter of the British American Nickel Corporation at Sudbury are being suspended until conditions improve.

MESSRS. GLOVER & WOOD, LIMITED, general ironfounders, have removed from the Viaduct Foundry, Kirkstall Road, to Larchfield Foundry, South Accommodation Road, Hunslet, Leeds.

CLYDE shipbuilding returns show that in February, 20 vessels of 83,278 tons were launched, making 29 vessels of 97,628 tons for the first two months of the year. This is a record for February.

IT is announced that the contracts for the steel work for forty road bridges required by the Public Works Department, Pretoria, have been awarded to the Cleveland Bridge and Engineering Company, Limited, of Darlington.

SPEAKING in Belfast after the launch of the 19,000-ton liner "Vandyck" Mr. William Boyd, director of Workman, Clark & Company, said the question of a reduction of wages in the shipbuilding industry would have to be faced.

THE ex-German steamer "Bismarck," 56,000 tons, the largest vessel in the world, recently acquired by the White Star Line for its Southampton, Cherbourg, and New York mail and passenger service, has been re-named the "Majestic."

IT was disclosed recently by Judge E. H. Gary, chairman of the United States Steel Corporation, that the directors had provided by resolution credit for foreign customers of the corporation to a total of $20,000,000 (£5,000,000).

IN one of the shipyards at Argenteuil on the Seine, just outside Paris, the management posted up a notice that the yard was closed, but the majority of the workmen decided to pay no attention to it and are continuing to carry on as usual.

AT the meeting of the Sheffield branch of the Institute of Junior Engineers held on February 25, a paper on "Testing Materials" was read by Mr. L. Stanfield, of the Brown-Frith research laboratory, and formerly of the Sheffield University.

THE production of pig-iron in the United States during January was at the rate of about 28,750,000 tons a year, or 10 per cent. under the December rate, 22 per cent. under the average in 1920, and 27 per cent. under the average in 1916—the banner year.

WITH reference to the application by the unions affiliated to the Federation of Shipbuilding and Engineering Trades for a public inquiry into the demand for a wage advance of 6d. per hour, it has been decided that the men must first submit the claim to arbitration.

THE applied science section of the University of Durham Philosophical Society held a meeting in Armstrong College on the 28th ult. to hear a paper entitled "A New Analysis of Some American Screw Propeller Tests," read by Mr. F. H. Alexander, M.Sc., lecturer in naval architecture.

A MEETING of the Merseyside branch of the Association of Engineering and Shipbuilding Draughtsmen was held recently in the Lecture Theatre of the Liverpool University, when Professor L. R. Wilberforce, D.Sc., delivered a lecture on "The Gyrostal: Its Uses and Applications."

THE cause of the cancellation of shipbuilding orders is the depression in shipping, and the fall in the value of tonnage, states Colonel Wilson, in "Parliamentary Debates." It was much cheaper to buy than to build, and it was not easy to make shipping pay. These causes were world-wide.

IT is understood that, while few orders for new ships were placed in this country in the later months of 1920, no orders have been booked by any shipbuilding firms since the present year opened, and a large number of forward contracts have been cancelled. There are now no inquiries for new tonnage.

SPEAKING at Sheffield to members of the Sheffield File Trade Technical Society, Dr. F. C. Thompson emphasised the need for accurate pyrometry in the heat treatment of file steels, seeing that the mere fact that a pyrometer was used was not by any means an adequate indication of the metallic charge.

THE closing for an indefinite period of the extensive ironworks of Messrs. William Dixon & Company—familiarly known in Glasgow as "Dixon's Blazes"—has thrown about 400 men out of employment, and has emphasized very strongly the depression which exists in the steel trade of the West of Scotland.

A MEETING of the Conciliation Board in the brass trade was held at Birmingham last week, when the proposal of the Employers' Association for a reduction in wages was considered. The Board decided to appoint a small joint committee of employers and employed, and the whole question was referred to this body.

MR. KELLAWAY, answering Mr. W. Carter (Lab., Mansfield) in the House of Commons, said an export credit scheme had been already set up, and the question of whether any modification could be made in that scheme, and credit provided in respect of the countries concerned, was receiving the active consideration of the Government.

A LECTURE was delivered by Mr. John H. Barker, M.Inst.C.E., before the students' section of the Institution of Civil Engineers in London, entitled "Machinery Applied to Mass Production," Mr. Summers Hunter, C.B.E., chairman and managing director of the North-Eastern Marine Engineering Company, Limited, presiding.

NO effort is being spared by German shipbuilders in their endeavour to secure orders abroad for new construction and repair work. In a circular distributed by a firm in Danzig it is stated that rush orders can now be undertaken owing to the promptness of steel deliveries from the mills and the large number of skilled workmen available.

IT is reported that an agreement has been entered into between M. Krassin, on behalf of the Russian Soviet Government, and the Slough Trading Company, for a large number of motor lorries, specially constructed and rebuilt for service in Russia. The agreement will come into force as soon as the trade agreement with Russia is signed.

MESSRS. G. A. HARVEY & COMPANY (LONDON), Suffolk House, Laurence Pountney Hill, E.C.4, announce that their galvanised tank list No. 225 is now subject to 60 per cent. discount instead of 55 per cent. as hitherto, and that their galvanising rates have been reduced 10 per cent., *i.e.*, tariff rates now being charged without any addition.

SIR FREDERICK MILLS, chairman of the Ebbw Vale Steel, Iron and Coal Company, Limited, speaking at a meeting of the Local Joint Industrial Council at Newport, said that the company would have to completely reorganise their whole concern before restarting work, adding that he was afraid that a very large number of men formerly employed by the company would not return.

LECTURING on "Health in Industry" at Caxton Hall recently, Dr. E. Halford Ross said that up to the present most of the work of prevention had been done in foreign countries, but the one place where it ought to be carried on was in industry. In London research had been promoted into the cause, the carriers, and the means of prevention of the most important disease in industry—consumption.

THE Mappin Hall, St. George's Square, Sheffield, was well filled recently, when Dr. P. Longmuir lectured on the heat treatment of carbon and alloy steels. The general precautions in heating of those steels before the processes of rolling or forging were discussed, with emphasis on the influence of mass and contour, and also the last aspect with regard to the annealing and casting of tool steel and wire.

AUTOMATIC AND ELECTRIC FURNACES, LIMITED, 281-283, Gray's Inn Road, London, W.C.1, inform us that Messrs. C. Lorenz Aktiengesellschaft, Berlin, have purchased the Wild-Barfield patent rights for Germany, Poland, and the former Austria-Hungary. Messrs. Lorenz have already placed a first order with Automatic and Electric Furnaces, Limited, for various parts to complete nearly one hundred furnaces.

FOR the first time in the history of the Institute of Metals, a contested election for the seven vacancies occurring on the Council is taking place. The candidates are as follows:—Mr. L. Archbutt, Mr. T. Bolton, Dr. W. H. Brownsdon, M.Sc., Engineer Rear-Admiral R. B. Dixon, C.B., Professor C. A. Edwards, D.Sc., Dr. R. S. Hutton, Mr. F. C. A. H. Lantsberry, M.Sc.Tech., Dr. R. Seligman, Mr. F. Tomlinson.

AT a meeting of the members of the National Brass and Metal Mechanics' Union on Friday last, occasion was taken to put before the meeting an application from the Brassfounders Employers' Association for a reduction in wages amounting to 15s. per week for men and 8s. per week for boys. After discussion, the following resolution was carried: "That, inasmuch as the Engineering Employers' Federation and the Engineering Federation of Working Men's representatives have agreed not to interfere with wages or earnings until six months after December 31, 1920, this meeting calls upon the Birmingham Brassfounders Employers' Association to stand by the national agreement and to withdraw the present application."

XUM

Company News.

Cessnock Engineering Company, Limited. — Capital £1,000 in £1 shares.

Dominion Steel Corporation, Limited.—Dividend of 1½ per cent., less tax, on common for quarter.

Bolckow, Vaughan & Company, Limited.—Interim dividend of 4 per cent., less tax, on ordinary.

Normanby Ironworks, Limited.—Dividend of 6 per cent. on ordinary and preference for past half-year.

Tyseley Foundry, Limited.—Capital £1,500 in £1 shares. Registered office: 40, Potter Street, Birmingham.

Heywood Foundry Company, Limited. — Capital £5,000. Directors: L. A. J. Smith, A. Hill and T. E. Livsey (secretary).

E. J. and H. E. Rose, Limited.—Capital £20,000, to carry on business as metal merchants, etc. Directors: E. J. Rose and H. E. Rose.

Jeffery & Taylor, Limited.—Capital £2,000 in £1 shares, to carry on the business of ironfounders. Registered office: 24 Moorfields, Liverpool.

North British Locomotive, Limited.—Dividend on the ordinary shares of 10 per cent., free of tax, for 1920. The dividend for 1919 was the same.

Laminated Gears, Limited.—After paying debentures interest, etc., profit for past year was £2,340. Dividend of 5 per cent. proposed, carrying £760 forward.

Bagnall's Forge & Engineering Company, Limited.—Capital £50,000 in £1 shares (10,000 preference). Registered office: South Hylton Works, near Sunderland.

Delta Metal Company, Limited.—Final dividend of 5 per cent. and bonus of 5 per cent., free of tax, making 15 per cent. for the past year, and carrying forward £11,179.

Wood & Lambert, Limited.—Capital £7,500 in £1 shares (6,000 preferred and 1,500 deferred), to carry on the business of engineers. Registered offices: 13, Old Burlington Street, W.

John Spencer & Sons, Limited.—The directors decided, in view of the uncertainty of the future, not to pay an interim dividend on the ordinary shares, but to carry forward the credit balance.

Brito Steam Blowers, Limited.—Capital £2,500 in £50 shares. Directors: W. P. Clyde, H. K. Denton, J. Lithgow, N. M. Magnussen, and T. H. Patterson. Registered office: 57, Bothwell Street, Glasgow.

British Tygard Engines, Limited.—Capital £15,000 in £1 shares. Ironfounders, mechanical engineers, shipbuilders, etc. Directors: Messrs. J. W. Tygard, A. B. Rogers, F. S. Gaylor, S. Stewart, and R. F. Power. 17, Victoria Street, Westminster, S.W.

Henry Besemer & Company, Limited.—Profit for 1920 was £28,431. Allocation of £5,000 for depreciation of plant and machinery recommended, and dividend of 5 per cent. on ordinary, making 10 per cent. for year, less tax, carrying forward £37,609.

Yorkshire Engine Company, Limited. — Profit, £14,516; debenture interest and bank charges, £2,443; excess profits duty and corporation profits tax, £3,500; balance, £8,572; brought forward, £21,635; preference dividends paid, £5,250; credit of profit and loss account, £24,957.

The British Wagon Company, Limited.—Out of the £55,419 7s. 9d. net profits of the year, the directors of the British Wagon Company, Limited, propose to transfer £5,000 to reserve, which will bring it up to £195,000, and to pay a further dividend of 6½ per cent., making the distribution for 1920 12½ per cent.

Leeds Forge Company, Limited.—Profits, £130,337; brought forward, £46,129; debenture interest, £7,500; directors' fees, £2,500; ordinary dividend, 7½ per cent.; income and corporation profits taxes, £36,372; reserve, £30,000; special depreciation fund, £20,000; amalgamation expenses, £8,995; carry forward, £30,149.

Deaths.

Mon. A. Gouvy, the eminent French metallurgist, died recently. During the war the deceased was responsible for installations for the heating of furnaces by heavy oils, previous to which he had superintended the manufacture of war materials in Russia. He was a member of the Iron and Steel Institute.

Mr. W. P. Snyder, chairman Messrs. W. P. Snyder & Company, of Pittsburgh, and a prominent figure in the United States iron and steel industry, died recently. In association with Mr. H. W. Oliver, Mr. Snyder was active in the development of Lake Superior iron ore, and acquired extensive holdings in that region.

Mr. T. Morris, manager of the Wellfield Galvanising Works, Llanelly, has died at his residence, The Grove, Old Road, in his forty-sixth year. He was a native of the Amman Valley, and had been long associated with the enterprises of Mr. Folland in that district before going to Llanelly to take charge of the Wellfield Works.

Gazette.

The Metric Engines, Limited, are being wound up voluntarily. Mr. T. D. Cocke, 44, Gresham Street, London, E.C., has been appointed liquidator.

Messrs. A. Dolman and D. J. K. Brown, brass finishers, 345, Chester Road, Cornbrook, Manchester, trading under the style of Alfred Dolman & Company, have dissolved partnership.

Resolved February 12 that the Richmond (Surrey) Foundry, Limited, be wound up voluntarily. R. L. Taylor, 24, Coleman Street, E.C., I.A., was appointed liquidator.

The partnership heretofore subsisting between Messrs. H. Rawnsley, B. Price, and W. L. Birch, engineers, etc., Eton Street, Halifax, under the style of Rawnsley, Price & Birch, has been dissolved.

The particulars heretofore subsisting between Joseph Perkins, Alfred Jno. Perkins, and Albert William Perkins, trading at Joseph Perkins & Sons, Clare Street, Northampton, engineers, has been dissolved. Debts by A. J. & A. W. Perkins, who continue the business.

The first meeting of the creditors of Mr. M. Henrick, sole proprietor of and lately trading as J. Wright & Company, Reliance Works, Liverpool Street, Birmingham, metal merchants and manufacturers, was held on March 9. The date of the public examination is March 23.

Personal.

The late Mr. George Hatch, Savoy Lodge, 70, Underhill Road, Lordship Lane, engineer's merchant, left £36,299.

Mr. William Leah, 225, Edgeley Road, Stockport, Cheshire, and of Messrs. Leah & Rowbotham, Limited, iron merchants, left £6,447.

Sir Henry O. Bax Ironside, K.C.M.G., and Sir William H. Porter, Bart., have been elected directors of the Westminster Electric Supply Corporation, Limited.

Mr. D. Richards, J.P., of Ammanford, of the Duffryn Works, Morriston, and the Bryn Works, Pontardawe, has been appointed high sheriff for Carmarthenshire.

Mr. Frank Gilbertson, president of the South Wales Siemens Steel Association and of the Swansea University College, has been ordered by his medical adviser to take a few days' rest.

The vacancy created in the board of Henry Bessemer & Company, Limited, by the death of Sir Charles Allen, has been filled by the appointment of Mr. Wostenholme, general manager of the Bolton works.

Mr. J. A. N. Barlow, C.B.E., who has been appointed Controller of the Training Department of the Ministry of Labour, in succession to Sir James Currie, is a son of Sir Thomas Barlow, the famous physician.

Mr. Arthur Strauss, of Kensington Palace Gardens, W., and of 16, Rood Lane, E.C., head of Messrs. A. Strauss & Company, metal merchants and brokers, left estate of the gross value of £181,388, with net personalty £174,636.

Mr. J. W. Sykes, who for several years has been connected with Messrs. Heywood & Porteous, Limited, of Gomersal, has now relinquished his position there, and has become a partner in the firm of the Perseverance Foundry Company, Gomersal.

In regard to the ascertainment of the average selling price of manufactured iron for the period covered by the last audit, the following are the selling prices for the last two months of 1920, compared with the previous audit and the corresponding audit of 1919:—Manufactured iron:—North of England (bars and angles), Nov.-Dec., £90 9, — 9 11¼, + 141 8¾; West of Scotland (rounds, squares, flats, tees, angles, hoops and rods), Nov. Dec., £99 7½, — 16 9¾, + 152 6½. In the North of England the wages of puddlers and millmen were reduced by 5 per cent., whilst in the West of Scotland the reduction amounted to 7½ per cent. The reduction in both districts took effect from January 31, 1921.

Among those who are to read papers at the spring meeting of the Institution of Naval Architects on March 15 to 18 are:—Sir Eustace d'Eyncourt, K.C.B., on "Some Features of German Warship Construction"; Mr. S. V. Goodall, on "The ex-German Battleship 'Baden'"; Mr. W. R. G. Whiting, on "The Strength of Submarines"; Messrs. R. J. Walker and S. S. Cock on "Mechanical Gears of Double Reduction for Merchant Ships"; Prof. T. B. Abell, on "The Framing of Ships"; and Mr. M. E. Denny, on "The Design of Balanced Rudders of the Spade Type."

IRON AND STEEL MARKETS.

Pig-Iron.

Stimulated probably by the increasing encroachments of Continental competition, Cleveland ironmasters, after a considerable period of hesitation, have decided upon drastic reductions in pig-iron prices, unprecedented, perhaps, in amount, more especially when contrasted with previous essays in this direction, which, at best, have only involved declines of a few shillings with, generally, some weeks between successive readjustments. Taking their courage in both hands, and facing the position boldly, the committee have decided to reduce the prices of all grades of Cleveland iron by 45s. per ton, and consequently No. 3 foundry, which at the end of 1920 figured at 225s., is now down to 150s. to take immediate effect. Although this figure is still higher than the Belgian quotations, there is little question that preference will be generally given by consumers to the home product, and doubtless result in an early expansion of business. It is, however, understood that the Belgian iron recently shipped to this country has been much more satisfactory in use than formerly, and no serious objection is raised to it in regard to quality, although many consumers still prefer Cleveland foundry pig. But it is quite evident that the Belgians have over-reached themselves. In their eagerness to get business they have sold below cost, and as a result buyers in this country are finding in many cases that they cannot get delivery. With regard to the prospects of an improved demand, it may be remembered that while prices were steadily falling buyers held off, but now that such a wholesale reduction has been made it will probably be realised that for some time at least finality has been reached in the downward movement, and that nothing further is to be gained by waiting. The new scale of prices for home consumption is as follows:—No. 1 Cleveland, 155s. per ton; No. 3 Cleveland G.M.B., 150s.; No. 4 foundry, 149s.; No. 4 forge and mottled, 147s. 6d.; white, 145s. per ton. For export there is in all cases a premium of 5s. per ton. If confirmation were needed of a change in the price position of Cleveland iron, ample justification is forthcoming in the returns of pig shipments from the Tees-side ports last month. In the figures presented for February may be readily realised the extent of the stagnation experienced in the trade of late, the total despatched amounting to 12,801 tons, of which 2,995 tons went coastwise, and 9,306 tons went abroad, as compared with 11,788 tons in January, an increase of 1,013 tons. The figures, though showing a small increase, can hardly be regarded as satisfactory, but it is nevertheless curious to note that during a month which has seen British pig-iron consumers importing large quantities of Belgian pig-iron, Middlesbrough has exported no less than 3,080 tons of pig-iron to Belgian ports. The only other countries to take any quantity of our pig-iron during February, apart from the two already named, has been France (710 tons) and Japan (750 tons), the total foreign shipments having reached 9,806 tons. In Scotland the announcement of the sensational decline in Cleveland prices, above recorded, has had a demoralising effect upon pig-iron prices, values in sympathy dropping from about 20s. to 25s. per ton. Some heavy shipments of Continental foundry pig-iron have been landed in Scotch ports recently, and although this is generally taking the place of Cleveland, the users of home products, tempted by the great disparity in prices, are inclined to risk the inclusion of foreign iron for blending purposes. The reduction in Middlesbrough prices still leaves an appreciable difference in favour of Continental foundry iron, which has been sold lately at £7 delivered consumers' works here, whilst the reduced price for Tees-side works out at £8 10s., delivered Scotland. No. 3 Scotch foundry, prior to the reduction in Middlesbrough this week, could be bought, delivered consumers' works, at a shade under the Middlesbrough price. To-day the difference is about 30s. in favour of Cleveland. It looks, therefore, as if we would see a further substantial reduction in Scotch prices. In Lancashire pig-iron markets considerable uncertainty as to the position exists. Buyers of foundry iron are doing very little just now, and do not seem to be anxious at all about their supplies, so that it is probable that a good deal of blowing out of furnaces may yet go on without causing a revival in the demand for such iron. It remains to be seen what effect the reduction in Cleveland prices will have on Midland pig smelters, the heavy cost of inland production in extra expenditure on transport of raw materials placing them in an extremely disadvantageous position compared with their competitors with handy sea-port facilities. In common with their ordinary iron contemporaries, hematite makers on the East Coast reduced the price by 40s. per ton, bringing the quotation for mixed numbers to 180s., with an extra 2s. 6d. for No. 1 grade, for both home consumers and export. Business in this section of the pig-iron market has been extremely quiet of late, home consumers buying practically nothing, while with the adverse rates of exchange abroad, foreign orders have been also confined within very limited dimensions. The substantial drop in hematite values, it is hoped, may stimulate better export business, but it may be feared that no very great improvement can be hoped for at home until an active revival of demand for steel eventuates. Business in Cumberland and North Lancashire in the hematite market continues depressed, although values are now reduced to £9 per ton, buying is almost at a standstill. There are very few furnaces in operation, most of the principal steel works in these districts having either already closed down, or reducing production, and in the absence of Continental inquiries the position gives cause for considerable anxiety.

Ore.

No improvement can be recorded in the foreign ore trade, merchants simply reporting "no business." Their nominal quotation for best rubio ore is 37s. 6d. per ton c.i.f., but as all consumers are over-stocked they are not on the market for new business. In the West Cumberland and North Lancashire native ore industry business is exceptionally quiet. None but the mines belonging to the two steelworks are working, all the privately owned pits having ceased operations. The demand for ore is purely local, and this is limited, because of the accumulations of foreign ores delivered under old contracts.

Scrap.

Markets everywhere remain practically stationary in condition, the demand for scrap of all qualities showing a decrease in volume corresponding with other raw materials of the smelting industries. In Lancashire, for example, one of the largest consuming districts for scrap material, heavy wrought scrap is now down to £6 per ton, but although it is comparatively cheap there is not a great demand for it. The Manchester market for cast scrap has been evidently waiting for some settlement of the foundry pig-iron market. The position in steel scrap is unchanged, no buyers coming forward, and no quotations are available.

Steel.

In all sections of the steel trade depression has reached an acute stage, and though in some districts, more than in others, less pessimistic views of the outlook are entertained the general opinion inclines to considerable delay before any substantial improvement can be confidently expected. The recent drastic reductions in pig-iron prices are, however, regarded as a hopeful indication of a return to more active conditions of trade, but whether this much desired result can be achieved in time to avert the worst consequences of the slump is quite another question. The inclusion of hematite iron in the reduction may be regarded as important as concerns consumers of acid steels and cheaper finished goods made from that material. In the Scottish steel trade inquiries are in fair volume, but from the business resulting it would appear as if buyers were merely testing the market. At the present time employment is becoming more and more scarce, many plants being now out of action, while those still running are going very slowly. The inflow of Belgian and French material continues, and it is said that fully 4,000 tons of finished and semi-manufactured material are finding their way to the Clyde and the Forth weekly. The latest reductions in steel prices have been unavailing so far. Makers of black steel sheets have now decided upon a reduction of £1 per ton in their prices, and ¼-in. gauge are quoted £22 per ton delivered at Glasgow stations, as against the top price of £38 10s. per ton reached before the middle of 1920. At Sheffield all the rolling mills are on short time, several of them having exhausted orders on hand being unable to obtain new work, while the forges are in even worse case. The heavy steel branches have also, it is to be feared, lost ground since last week, at any rate, in this district, and two considerable local works are practically closed down. There is no business passing in British soft basic material, and it is impossible to say what its current value is, because no quotations are being given or asked for. Nominally, the figures are £16 or £17, but if £15 were quoted it would make no difference, because it could not compete with Continental steel at from £10 10s. to £11 for reliable brands. As regards basic material, the mills in operation are working entirely on imported steel.

Finished Iron.

Conditions in the finished iron branches continue unsatisfactory, and in actual fact are more depressed than has been the case for some years. In the South Staffordshire districts demand has almost reached a diminishing point, and a number of the mills are idle, even makers of marked bars who were comparatively well provided with orders when the slump commenced, are working off old contracts to their termination with a poor prospect of new specifications to follow. The market for the lower grade bars is very quiet, and in many cases Continental steel material at cheaper prices is being accepted by consumers. In consequence, the Associated bar makers have reduced prices by £2 per ton for both marked and crown qualities. The movement has, however, had little influence on buyers so far, and not much forward business has resulted. The market for gas strip is also disappointing, hopes of a revival in this branch not having materialised, although prices have been reduced £2 per ton, and it must necessarily be some time before any substantial recovery in demand can be expected. It is, of course, too early to anticipate the effects of the recent reductions in pig-iron on the well-being of the finished iron trade, and meanwhile the industry in the Black Country continues only partially employed. For some time the chain trade in the Cradley Heath district has been in a depressed condition. This is attributed largely to the fact that huge stocks of unused chain held by the Admiralty and War Office are being released for sale. Most of the small factories in the industry have been closed, and the bulk of the workers at the larger factories are on short time. At a meeting of malleable bar iron makers, held in Glasgow last week, it was decided to cut prices to the extent of £2 per ton, and from now the quotation for crown quality will be £23 per ton delivered at Glasgow stations, compared with £30 per ton touched in May or June last year

Refractories.

The position of the refractories trade during the last week has not undergone much change, but orders are steadily coming in. The demand for magnesite bricks is constant, and manufacturers have been able to effect a slight reduction in price, the current prices being given in the list in another part of this journal. The crucible steel trade in the Sheffield district remains at a standstill practically. Generally speaking prices remain firm, though refractory material manufacturers are inclined to quote easier terms to firms who will consider placing contracts for supplies. Good stocks are being held by all manufacturers, and there is a little indication of some improvement in business in the early future.

Tinplates.

Conditions in the tinplate trade so far show little signs of improvement, and are practically unchanged, except that the process of price deflation has been accelerated by the prevailing stagnation of demand. It is now reported that the orders in hand are rapidly becoming exhausted, and practically no new buying is in evidence, though there has been an inquiry or two from Holland and Scandinavia, and a small order from Belgium. The condition of the sheet and tinplate industries can be gauged from the fact that in January there were only 157 tinplate mills in operation, as compared with 388 in the same month of last year. Since then there have been many further stoppages. Tinplates are again lower in price, being now down to 27s. 6d. basis f.o.b., but 30s. is being quoted for forward business. It is stated that with tinplates at 27s. 6d., and tin bars remaining at the official minimum of £14 10s. per ton, tinplate makers are losing 6s. per box on bare cost of production. It is the concensus of market opinion that much time must elapse before there can be any revival of trade on Continental account, and in this connection it is stated that considerable stocks of tinplates are held, particularly in France and Denmark. The hope is, however, entertained that with the improved labour position in Italy some demand may spring up from that quarter. The current prices are:—Cokes, 20 by 14, 28s. to 30s.; ditto quarters, 31s. to 32s.; cokes, 20 by 10, 42s. 6d. to 43s. 6d.; ditto 28 by 20, 55s to 62s; ternes, 28 by 20, 58s to 60s. In regard to wasters, 28 by 20 can be bought easily at 40s., CW. 14 by 20 at 20s., and CW. 14 by 18¾ at 15s. 6d., all net f.o.t. at works.

Furnace Coke.

With the diminished demands of pig-iron smelters, buying in the market for furnace coke is now on a limited scale, and oven plants are only working at reduced outputs. In order to stimulate trade, the price has been reduced a further 10s. per ton, making the price of blast-furnace coke for inland purposes 45s. per ton on rail at ovens, and for export 55s. f.o.b. A reduction of 10s. 9d. per ton had been previously made in January, but this was not considered adequate by the ironmasters, who felt compelled to stop buying except for immediate needs. The new price takes effect from March 1, and it is hoped to do something to remove the depression in the pig-iron trade. Other makes of coke are unaffected. Steel-smelting coke remains at 85s. to 86s. per ton delivered at works, and patent oven qualities 75s. per ton.

Metals.

Copper.—The market for standard copper opened this week under quiet conditions, with a shade weaker tone in forward metal, disclosing a decline of about 15s. Buying has only been of a desultory character of late, and that tendency has continued to prevail, movements of operators being only hand-to-mouth, and mostly confined to the more urgent requirements of consumers. The volume of demand for consumers, both at home and abroad, is only on a limited scale, and the market closed quiet, with refined weaker, electrolytic and wire bars showing declines of 20s. on the day. Closing prices:—Cash: Wednesday, £67 10s.; Thursday, £67 12s. 6d., Friday, £68 15s.; Monday, £66, Tuesday £66. Three Months: Wednesday, £67 5s.; Thursday, £67 7s. 6d.; Friday, £67 5s.; Monday, £66 5s; Tuesday, £66 5s.

Tin.—With business reported quiet in the East, the market here for standard tin opened with a lower tone, this month's metal showing a decline of about 20s. at £152. Only a moderate business was passing on forward account, three months being quoted down to £155, about 40s. below Friday's closing price. Subsequently a more active buying movement developed and prices responded to the upward tendency, showing a recovery of the previous declines, and closing practically unchanged with a fairly firm tone. English ingots were quiet but steady at an advance of 10s. The weekly return of stocks in London warehouses shows an increase of 63 tons to 4,826; Liverpool stocks are also increased at 2,264, and Swansea unchanged at 142 tons. Closing prices:—Cash: Wednesday, £155 10s.; Thursday, £154 15s.; Friday, £153; Monday, £153; Tuesday, £150 15s. Three Months: Wednesday, £159 10s.; Thursday, £154 15s.; Friday, £156 10s.; Monday, £156 10s.; Tuesday, £154 10s.

Spelter.—The week's markets opened with a fairly general demand from consumers, and consequently values showed a brisk upward tendency both for near and forward metal. At the close ordinary brands prompt were quoted £26 10s., a substantial advance over last week's final prices English was steady at £27 10s., and electrolytic 99 per cent. at £34.

Lead.—With consumers again inclined to hold off buying, and sellers freely offering, the market for lead has continued quiet and on balance near and forward soft pigs have declined about 10s Foreign closed for prompt and March at £18 2s. 6d., with English also lower at £20.

GANISTER, CUPOLA BLOCKS, FIRE BRICKS,
FIRE CLAY.
Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.
STEEL MOULDERS' COMPOSITION, SILICA CEMENT.
J. GRAYSON LOWOOD & Co., Ltd.,
DEEPCAR nr. SHEFFIELD.
Telegrams: "LOWOOD, DEEPCAR."

BRITISH STEEL FOUNDERS!

THE WAR SHOWED YOUR
ABSOLUTE DEPENDENCE ON
FOREIGN SANDS

☛ THE SAME WAR SET YOU FREE

and provided you with an All-British Sand freely admitted by British and even some Belgian Steel Founders to be better in every way than any imported Sand, and known the country over as

"YORKSHIRE SAND"

which strips cleaner, needs less nails, carries greater weights, is more regular, stands more mixing sand than any French or Belgian Sand on the market, and is

CHEAPER IN EVERY WAY.

Why return to the Foreign Yoke?
Why create more unemployment at home?
Why send British money out of the country?

THE GENERAL REFRACTORIES Co., Ltd.
KELHAM ISLAND, SHEFFIELD,

Telephone: 3577 (2 lines) *Telegrams: Refractory, Sheffield*

WILL BE PLEASED TO DEMONSTRATE TO YOU

(1) *The Best way to use "Yorkshire Sand."*
(2) *That it is cheaper than any Foreign Sand.*
(3) *That it is better in every single respect.*

YORKSHIRE SAND IS SUPPLIED IN 4 GRADES.

"EXTRA STRONG" as a binder for Silica Sands which we can supply cheaper and better than anyone else.

"STRONG" for large work, and to be let down for medium and small castings.

"ORDINARY" for medium stoved work, and may be let down for small castings if desired.

"GREENSAND" ready for use for Skin-dried, Greensand and Light Stoved Work.

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash ..	66	0	0
Three months.. ..	66	5	0
Electrolytic	71	0	0
Tough	68	10	0
Best selected	68	10	0
Sheets	116	0	0
India	116	0	0
Wire bars	72	10	0
Do. April	72	0	0
Do. May	72	0	0
Ingot bars	71	10	0
H.C. wire rods.. ..	79	0	0
Off. aver. cash, Feb.	71	0	9
Do. 3 mths., Feb..	70	14	10½
Do. Settlement Feb.	71	0	4½
Do. Electro. Feb..	76	15	6
Do. B.S., Feb. ..	75	1	10½
Aver. spot, copper.. Feb.	71	0	0
Do. Electro, Feb...	77	12	6

Solid drawn tubes .. 16½d.
Brazed tubes .. .. 16½d.
Wire .. .. .. 13d.
Yellow metal rods.. 9d.
Do. 4x4 Squares .. 11½l.
Do. 4x3 Sheets .. 11½l.

BRASS.

Solid drawn tubes.. 14¼d.
Brazed tubes 17½d
Rods .. .. .. 13½d.
Sheets to 10 w.g. .. 12¾d.
Wire .. .. .. 12⅝d.
Rolled metal .. 12¼l.

TIN.

	£	s.	d.
Standard cash ..	150	15	0
Three Months.. ..	154	10	0
English	150	0	0
Bars	152	0	0
Chinese	146	0	0
Straits	164	0	0
Australian	163	0	0
Eastern		—	
Banca	173	0	0
Off. aver., cash, Feb.	166	9	1½
Do. 3 mths., Feb ..	170	16	3
Do. Sttlment., Feb.	166	6	6
Aver. spot, Feb. ..	166	5	3

SPELTER.

Ordinary	26	5	0
Remelted	21	0	0
Hard	18	0	0
Electro 99.9	34	0	0
English	27	10	0
India	22	10	0
Prime Western ..	24	15	0
Zinc dust	60	0	0
Zinc ashes	6	5	0
Off. aver., Feb. ..	25	5	5½
Aver., spot, Feb. ..	22	17	0

LEAD.

Soft foreign ppt ..	18	2	6
English	20	0	0
Off. average, Feb...	21	0	0
Average spot, Feb.	20	13	7½

ZINC SHEETS.

Zinc sheets, spot ..	36	0	0
Do. V.M. ex. whf	38	0	0
Do. ppt., f.o.b., N.Y.		—	
Dutch	36	0	0
Boiler plates	34	10	0
Battery plates ..	33	10	0

ANTIMONY.

English regulus ..	37	5	0
Special brands ..	42	0	0
Chinese	23	0	0
Crude	19	10	0

QUICKSILVER.

Quicksilver. 12 5 0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—
45/50% 18 0 0
75% 26 10 0
Ferro-vanadium—
35/40% .. 26/- lb. va.
Ferro-molybdenum—
70/80% .. 7/9 lb. mo.
Ferro-titanium—
23/25%, carbonless 1/9 lb.
Ferro-phosphorus, 20/23%, £36
Ferro-tungsten—
80/85%, carbon free 1/10 lb.
Tungsten metal powder—
98/99% .. .. 3/- lb.
Ferro-chrome—
4/6% car. £37 10
6/8% car. £37
8/10% car. .. £36 10
Ferro-chrome—
Max. 2% car. .. £86
Max. 1% car. .. £102
Max. 0.75% car. .. £119
65/75%, carbonless 3/- lb.
Nickel—99·8%, cubes or pellets .. £200
Cobalt metal—97%.. 20/- lb.
Aluminium—98/99% £150
Metallic Chromium—
98/99% .. .. 6/6 lb.
Ferro-manganese—
76/80%, loose .. £25
76/80%, packed .. £26
76/80%, export .. £22 10
Metallic manganese—
98/99%, carbonless 3/2 lb.
Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

	s.	d.
Finished bars, 14% tungsten	3	2
Finished bars, 18% tungsten	4	0
Scrap pieces	5d.	
Turnings and swarf..	3d.	

Per lb. net, d/d buyers' works.

Extras—
Rounds and squares 3 in. to 8 in. inclusive 4d. lb.
Rounds and squares under ½ in. to ¼ in. 3d. lb.
Flats under 1 in. by ⅜ in. to ½ in. by ¼ in., and all sizes over four times in width over thickness .. .. 3d. lb.
Bevels of approved sizes and sections .. 6d. lb.
If in coils .. .. 3d. lb.
Packing .. ..4s. cwt
Bars cut to length 10% extra
Scrap from high-speed tool steel—
Scrap pieces .. .. 5d.
Turnings and swarf .. 3d.
Per lb. net, d/d steel makers' works.

SCRAP.

	£	s.	d.
South Wales—£ s. d.			
Heavy Steel	4	0	0
Bundled steel & shearings	4	0	0
Mixed iron & steel ..1 10 0	4	10	0
Heavy cast iron ..	5	10	0
Good machinery for foundries. ..	7	10	0
Cleveland—			
Heavy steel ..	4	0	0
Steel turnings ..	3	15	0
Cast-iron borings	3	15	0
Heavy wrought iron piling	7	0	0
Bundling scrap ..	6	10	0
Cast-iron scrap ..	8	0	0
Lancashire—			
Cast iron scrap ..	9	5	0
Heavy wrought ..	6	0	0
Steel turnings ..	3	15	0
London—			
Copper (clean) ..	55	0	0
Brass (clean) ..	32	0	0
Lead (less usual draft)	13	0	0
Tea lead	11	0	0
Zinc	12	0	0
New aluminium cuttings ..	70	0	0
Braziery copper ..	45	0	0
Gun metal ..	49	0	0
Hollow pewter ..110		0	0
Shaped black pewter	70	0	0

PIG-IRON.

N.-E. Coast—
Foundry No. 1 .. 155/-
Foundry No. 3 .. 150/-
Forge No. 4 .. .. 149/-
Mottled 147/6
Hematite No. 1 .. 182/6
Hematite M/Nos. .. 180/-
Midlands—
Staffs. common .. 175/-
„ part-mine forge 190/-
„ „ foundry 200/-
„ Cold blast .. 360/-
„ basic 165/-
Northants forge .. 170/-
„ foundry No. 3 190/-
„ basic.. .. 170/-
Derbyshire forge .. 190/-
„ foundry No. 3 195/-
„ basic .. 190/-
Scotland—
Foundry No. 1 .. 200/-
„ No. 3 .. 195/-
Hematite M/Nos. .. 200/-
Sheffield (d/d district)—
Derby forge 200/-
„ foundry No. 3 210/-
„ basic 200/-
Lincs. forge 190/-
„ foundry No. 3 195/-
„ basic 162/6
E.C. hematite .. 193/-
W.C. hematite .. 196/-
All d/d in the district.
Lancashire (d/d eq. Man.)—
Derby forge .. .. —
„ foundry No. 3 —
Northants foundry No. 3 .. .. —
Cleveland foundry No. 3 .. .. —
Staffs. foundry No. 3 —
Lincs. forge .. .. —
„ foundry No. 3 —
Summerlee foundry.. 225/-
Glengarnock foundry 232/6
Gartsherrie foundry 223/-
Monkland foundry .. 225/-

FINISHED IRON & STEEL.

Iron—	£	s.	£	s.	d.
Bars (cro'n)	22	0	24	10	0
Angles ..	22	10	25	0	0
Tees to 3 united ins. ..	23	0	25	10	0
Nut and bolt ..			22	0	0
Hoops			26	5	0
Marked bars (Staffs.) ..			27	10	0
Gas strip ..			26	0	0
Bolts and nuts, ¾ in. × 4 in.			47	0	0
Steel—					
Ship plates ..			21	0	0
Boiler plates ..			27	10	0
Chequer plates			24	0	0
Angles			19	10	0
Tees			20	10	0
Channels ..			19	10	0
Joists			19	0	0
Rounds, ⅜ in.–3-in.			19	0	0
Rounds, 3 in.–5½ in. ..			18	0	0
Flats, 5 in.–8 in.			18	10	0
Flats over 8 in.			18	0	0
Rails, heavy ..			18	0	0
Fishplates ..			23	0	0
Hoops			20	0	0
Black sheets, 24 g.			23	10	0
Galv. cor. sheets, 24 g.			24	10	0
Galv. fencing wire, 8 g. plain ..			30	10	0
Rivets, ¾ in. dia			36	0	0
Billets, soft ..			13	10	0
Billets, hard ..			14	10	0
Sheet and tin bars			14	10	0

PHOSPHOR BRONZE.

Rolled.	Per lb. s.	d.
½ in. to 1 in. wide ..	1	11¾
1 in. to 1½ in. wide ..	1	11½
1½ in. to 2 in. wide ..	1	9¾

Strips.	s.	d
2 in. to 6 in. to 26 S.W.G.	1	9¼
6 in. to 12 in. to 26 S.W.G.	1	9½

Sheets.	s.	d.
12 in. to 18 in. to 24 S.W.G.	1	9½
18 in. to 24 in. to 24 S.W.G.	1	10¼
24 in. to 30 in. to 20 S.W.G.	1	11¼
30 in. to 36 in. to 16 S.W.G.	1	11¾
36 in. to 42 in. to 16 S.W.G.	2	0¾

Extras.

For Gauge: Any width up to 36 in. wide, ¼d. per lb. per thinner gauge.

Drawn Rods.	s.	d.
¼ in. to ½ in. dia. in random lengths / ⅛ in. to 1½ in. dia. in random lengths	1	10
Over 1½ in. to 1¾ in. ..	1	10
Tubes—basis price ..	1	11¾

Delivery 2 cwt. free to any town.
10% phosphor copper, £40 above price of B.S.
15% phosphor copper, £50 above price of B.S.
Phosphor tin (5%), £30 above price of English ingots.
Charles Clifford & Son, Limited, Birmingham.

NICKEL SILVER, SHEET METAL, WIRE AND TUBES.

	Per lb.
Ingots for raising	1/3 to 1/9
Rolled—	
To 9 in. wide	1/10½ to 2/4½
To 12 in. wide	1/11 to 2/5
To 15 in. wide	2/– to 2/6
To 18 in. wide	2/1 to 2/7
To 21 in. wide	2/2 to 2/8
To 24 in. wide	2/3 to 2/9
Ingots for spoons and forks ..	1/3 to 1/9
Ingots rolled to spoon size ..	1/6 to 2/–
Wire round—	
3/0 to 10. G. ..	2/1 to 2/8

with extras according to gauge

AMERICAN IRON & STEEL.

At Pittsburgh unless otherwise stated.	Dols.
No. 2X foundry, Phila.	30.09
No. 2 foundry Valley..	27.00
No. 2 foundry, Birm. ..	27.50
Basic	26.96
Bessemer	28.96
Malleable	28.96
Grey forge	27.96
Ferro-manganese, Atl. port	90.00
Bess. rails, h'y, at mill	45.00
O.-h. rails, h'y, at mill	47.00
Bess. billets	38.50
O.-h. billets	38.50
O.-h. sheet bars ..	42.00
Wire rods	52.00
	Cents.
Iron bars, Phila. ..	2.70
Steel bars	2.00
Tank plates	2.15
Beams, etc.	2.15
Skelp, grooved steel ..	2.45
Skelp, sheared steel ..	2.65
Steel hoops	2.80
Sheets, black, No. 28 ..	4.10
Sheets, galv., No. 28 ..	5.25
Sheets, blue an'l'd, 9&10	3.20
Wire nails	3.10
Plain wire	3.00
Barbed wire, galv. ..	3.85
Tinplate, 100-lb. box ..	$7.00

COKE.

Welsh foundry	72/6
„ furnace	57/6
Durham & North foundry	70/-
„ furnace	54/6
Other Districts, foundry	77/9
„ furnace	45/-

SWEDISH IRON.

Bars, hammered basis sizes ..	Basis price. £ s. d.
Rolled Ordinary—Assortment ..	31 0 0 to 38 0 0
Nail Rods—Square, round and flats ..	
Keg Steel } about Faggot Steel } £50	Prices nominal.
Blooms—Single welded ..	£20 to £25
Billets—Single and double welded ..	£22 to £27
Pig-Iron—Grey, white or mottled ..	£15 to £20

Prices are without engagement. All quotations are f.o.b. Gothenburg, net cash against documents there.

TUBES.

	Up to and incl. 2 in.	Over 2 in.
Gas ..	— 5%	—10%
Water ..	+ 5%	— 2½%
Steam ..	+16½%	+ 8¾%

REFRACTORIES.

	£	s.	d.
Magnesite bricks, 2½ in., d/d	130	0	0
Do. 3 in., d/d	156	0	0
Common firebricks, 2½ in., d/d	10	0	0
Do. 3 in., d/d	12	0	0
Scotch firebricks, 2½ in., f.o.r.	12	15	0
Do. 3 in., f.o.r.	15	7	6
Sheffield quality, 2½ in., f.o.r.	11	0	0
Do. 3 in., f.o.r.	13	5	0
Silica bricks (ord.), 2½ in., f.o.r.	14	18	6
Do. 3 in., f.o.r.	17	18	6

All per 1,000 bricks.

Basic Dolomite ..	3	18	0
Dead burnt magnesite (peas and powder), d/d ..	22	10	0
Ground fireclay	1 10 0 to 2	0	0
Ganister	1 10 0 to 1	12	6

TINPLATES.

I.C. Cokes, 20×14, box	28/-
,, 28×20, ,,	55/-
,, 20×10, ,,	42/6
,, 18¾×14, ,,	31/-
Terneplates, 28×20, ,,	58/-

DAILY FLUCTUATIONS.

Standard Copper (cash).

	£	s.	d.		
Mar. 2	67	10	0	dec.	15/-
,, 3	67	12	6	inc.	2/6
,, 4	66	15	0	dec.	17/6
,, 7	66	0	0	,,	15/-
,, 8	66	0	0	No change	

Standard Tin (cash).

Mar. 2	155	10	0	dec.	50/-
,, 3	154	15	0	,,	15/-
,, 4	153	0	0	,,	35/-
,, 7	153	0	0	No change	
,, 8	150	15	0	dec.	45/-

Zinc Sheets (spot).

Mar. 2	36	0	0	dec.	20/-
,, 3	36	0	0	No change	
,, 4	36	0	0	No change	
,, 7	36	0	0	No change	
,, 8	36	0	0	No change	

Spelter (ordinary).

Mar. 2	23	10	0	dec.	5/-
,, 3	23	12	6	inc.	2/6
,, 4	23	15	0	inc.	2/6
,, 7	24	5	0	inc.	10/-
,, 8	26	5	0	inc.	40/-

Lead (English).

Mar. 2	20	0	0	inc.	10/-
,, 3	20	10	0	,,	10/-
,, 4	20	10	0	No change	
,, 7	20	0	0	dec.	10/-
,, 8	20	0	0	No change	

SHROPSHIRE IRON Co., Ltd.

Works:—
Hadley, Shropshire.

Telegrams:—
Sun, Wellington, Salop.
Sunbrand (Cannon), London.

London: 10, Bush Lane, Cannon St., E.C.4.

Telephone:—
11 Wellington, Salop.
5959 Central.

BARS, HOOPS, SECTIONS & WIRE
in IRON, STEEL, COPPER and BRONZE.

Galvanised Telegraph, Telephone, Cable and Trolley Wire
To all Specifications.

Contractors to H.M. Government (Admiralty, G.P.O., India Office, War Office, Colonies), English and Foreign Railways, &c.

BEST H. C. COPPER & BRONZE WIRE a speciality.

Medals:—Sydney (Bronze) 1879, New Zealand (Gold) 1882, Liverpool (Silver) 1886, Adelaide (Gold) 1887, Franco-British Grand Prix (Highest Award) 1908.

ROBERT HEATH & LOW MOOR, LIMITED,
Stoke-on-Trent.

B.B.H. IRON.
At works.
BARS, ANGLES, TEES and PLATES.

R.H. ✠ IRON.
Delivered F.O.B. Liverpool.
BARS, ANGLES, TEES and PLATES.

HOOPS delivered F.O.B. Liverpool.

IRON
R.D. ✠
RAVENSDALE (Best)

MILD STEEL (up to 2in. wide)
Marked
"HEATH'S SOFT STEEL."

Prices on Application.

WILLIAM JACKS & COMPANY,
5, EAST INDIA AVENUE, LONDON, E.C.3.

Telegrams: ALKALIZE, BIRMINGHAM.
Telephone: CENTRAL 1175 & 1176
Birmingham Office:
15, BENNETT'S HILL.

Telegrams: ALKALIZE, LONDON.
Telephone: 7880 AVENUE (3 lines.
Head Office:
5, EAST INDIA AVENUE, London, E.C.

REGISTERED TRADE MARK

PIG IRON.

Scotch, Middlesbro,' Hematite, Basic, Specials, &c., &c.

TIN — SPELTER — CHROME
COPPER — ANTIMONY—MANGANESE.

WILLIAM COLVIN & COMPANY,

ROYAL EXCHANGE.
MIDDLESBROUGH.

93, HOPE STREET.
GLASGOW.

SITUATIONS.

LEADING FOUNDRY FOREMAN (37) desires change. Highly skilled in ironfounding and non-ferrous, metallurgy, moulding machines; high-class work, jobbing and repetition, heavy and light. Successful control of men.—Box 702, Offices of the FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

FOUNDRY FOREMAN, brass and aluminium, seeks engagement; thorough practical moulder, with experience in the mixing of metals and tilting furnaces; motor, plumbers, and general engineering castings; conversant with the best methods of production, machine and plate work, also floor work, with expert knowledge of art and ornamental work, memorial plates and figure work. Good organiser, and a good knowledge of piecework prices. Would take entire management of foundry or would start same. Age 40. Excellent references. Midlands preferred.—Box 704, Offices of the FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

FOUNDRY MANAGER, first-class all round experience, desires position. Advertiser has an excellent London foundry connection, and can secure inquiries and orders for engineers' castings.—Box 706, Offices of the FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

ENGINEER REPRESENTATIVE, age 30 years, open for re-engagement; would consider representing two firms or one only; well connected amongst engineers, etc.; experienced in all engineers' requirements and foundry plant; Lancashire and Yorkshire ground preferred, but not essential. Would be pleased to entertain the Colonies or U.S.A., having successfully worked New York. Highest references from important firms.—HALL, 48, Withnell Road, Blackpool.

FOUNDRY MANAGER, or Head Foreman. Iron, brass, aluminium, etc. Produce at lowest costs drysand, greensand, loam and machine moulding. Good controller and organiser.—Write, Box 708, FOUNDRY TRADE JOURNAL, 5, Duke Street, Adelphi, Strand, London, W.C.2.

HEAD FOREMAN wanted for large Bronze and Brass Foundry. Applicants must be first-class men on reverbatory furnaces, melting high-class bronzes and gunmetals for propellers and ships castings to Admiralty requirements; knowledge of machine moulding essential.—State age, experience, and wages to Box 698, Offices of the FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

STEEL MOULDER, experienced small castings, alloy steels, etc., moulding machines, sand, required to organise production of small foundry commencing quality castings, Liverpool district.—State age, full experience, wages required, E47, BIRCHALL'S ADVERTISING OFFICES, Liverpool.

TENDERS

G. R.

BY DIRECTION OF THE DISPOSAL BOARD.

TENDERS FOR BREAKING DOWN AND PURCHASE OF SURPLUS AIRCRAFT.

The Disposal Board invites tenders for the breaking down in Antwerp of Aircraft, Aircraft Engines and Spares, and the purchase of the resultant scrap material, consisting of Cast Iron, Steel, Aluminium Brass, Timber, Rubber, Fabric, Boxes and Packing Cases, etc., to a total weight of approximately 600 tons. All inquiries should be addressed to :—

Capt. D. M. Mackie,
C/o British Consulate General,
ANTWERP,

and inspection of the material can be arranged.

Form of tender, conditions of contract and approximate schedule of quantities may be obtained on application to :—

The Controller, D.B.5,
Block "A,"
Earl's Court, S.W.5,

or to :—

The Disposal Board Representative,
C/o British Consulate General,
ANTWERP.

The tenders, enclosed in sealed envelope, addressed to Capt. D. M. Mackie, c/o British Consulate General, Antwerp, and endorsed "Tender for Aircraft Material," must be delivered at the British Consulate, Antwerp, not later than 10 a.m. on the 24th March.

MACHINERY.

FOR SALE.

13 SETS OF DIESEL OIL ENGINES, 200/250 h.p., 320/420 revs.

VERTICAL COMPOUND STEAM VACUUM PUMP, 6 in. and 12 in. steam cyls., 17 in. air cyls., 1,000 cubic feet capacity.

TWO SPINDLE HEAVY DUTY VERTICAL DRILLING MACHINE, sliding table, 4 ft. x 6 ft.

RACK DRIVEN PLANING MACHINE, 8 ft. x 3 ft. x 3 ft., with two tool boxes, by Butler & Company

One No. 2 Kempsmith Universal MILLING MACHINE, with vertical attachment and equipment

12/14 in. stroke SLOTTING MACHINE, by Butler & Company.

Six 18 in. CENTRES, all geared Head S.S.S. Lathes, 34 ft. 6 in., for motor drive, by G. & A. Harvey.

One No. 9 PULSOMETER PUMP.

DOUBLE RAM CAMERON-TYPE PUMP, steam cyls. 17 in., 15 in. stroke rams, 11 in. dia.

Three Motor Driven Shunt Wound, Worm Geared BOLLARDS, 220 volts, 14 amps, 680 revs.

STEAM DRIVEN ASH HOUSTS, by Messrs. Alley & MacLellan, 4½ in. cyl., 5 in. stroke.

CATALOGUE OF STOCK MACHINERY, 5-6,000 LOTS, FREE ON APPLICATION. INSPECTION INVITED.

THOS. W. WARD, LTD.,
ALBION WORKS, SHEFFIELD.
Telegrams : "Forward, Sheffield."
Telephone : 4321 (8 lines).

ADVERTISER wishes to purchase a 1-ton or 30-cwt. Electric Furnace, for steel making; secondhand equipment desired. State type and full details of plant and price required.—Reply to Box 680, Offices of the FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

PARTNERSHIPS.

PARTNER wanted for Foundry, with good connection in the North of Scotland. Foundry experience necessary, with capital of £1,200.—Box 700, Offices of the FOUNDRY TRADE JOURNAL, Bessemer House, 5, Duke Street, Adelphi, London, W.C.2.

MISCELLANEOUS,

FOR SALE.—"Locomotive" Gauge, 2 ft. 10 in., wheel base 3 ft. 6 in., bore 6 in., stroke 10 in., saddle back, copper firebox, brass tubes. Also wagons and rails.—ASHTON & HOLMES LTD., Macclesfield.

WANTED all users of METALLIC CEMENT to buy our PEERLESS brand, which produces "Artificial Iron" 10 lb. tin 10s., free delivered.—WILLIAM OLSEN, LTD., Cogan Street, Hull.

PATTERNS and CASTINGS SUPPLIED WHICH GIVE SATISFACTION. Inquiries solicited. Quotations by return of post or telephone. You can secure good-class work, reasonable prices, and promptitude in delivery by placing your orders with VIDEX PATTERN WORKS AND FOUNDRY, Huntsworth Mews, Upper Baker Street, London, N.W.1. (Telephone, Paddington 364).

ADVICE and Handbook Free. — KING'S PATENT AGENCY, LIMITED, Director, B. T. King, Reg. Patent Agent, 146a, Queen Victoria Street, E.C.4.

THE Standard Minerals Co. supply at lowest prices Foundry Coke, Purified Breeze, Ganister, Fire Clay and Bricks, Limestone, Spar, and Moulding Sand to suit all requirements.—THE STANDARD MINERALS CO., 136-138, Mansfield Road, Nottingham.

FOUNDRY REQUISITES.—Straw Rope, Core Gum, Core Vent, Plumbago, Blacking, Coal Dust, Riddles, Sieves, Bellows, etc. Prompt delivery. Lowest prices.—LYNDHURST MANUFACTURING CO., 25, Sherwood Rise, Nottingham.

FOR SALE, cheap, Foundry Pig Iron, all sections, F.B. Steel Rails, with all accessories; Joists, Channels, Angles, Sheets and Plates, all thicknesses; plumbago.—Ascog, Golder's Green, London. Telephone; Hampstead, 1806.